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EDITORIAL.

One of the most popular of indoor sports to-day is criticising all educational institutions and especially those of college and university grade. We are assured on all sides that educators and educational processes are all wrong and that, because of this, the world is doomed to destruction. The technical colleges in particular have received more than their share of this critical attention. On every hand we find "Committees on Education" willing and anxious to tell us what is wrong and how to mend it; all of these activities offering suggestions and even demands that educators mend their ways.

Curiously enough these many criticisms have not, apparently, resulted in any marked changes in engineering curricula. Here and there a few radical departures from accepted methods may be noted but, as yet, these departures have developed little or nothing that would warrant their universal adoption. Educators apparently are self satisfied or are not convinced, as yet, that their methods are radically and fundamentally wrong. No thoughtful man, of course, would contend that the engineering colleges are perfect; no human institution ever has been. But when one views the steady growth of these institutions, the tremendous influence their graduates have exerted upon industry, and especially when it is noted that the flood of new students toward these institutions constantly increases, proportionately, the apparent complaceny of the average college professor is not difficult to understand.

The criticisms referred to in the foregoing come from two principal sources. The first is alumni opinion. This is a most important source for it is a kindly, interested criticism and based upon a considerable knowledge of what the institution under discussion aims to do, and its shortcomings toward that end. Intelligent alumni criticism is most valuable and is not to be ignored. Its weakness lies in the fact that the expe-

riences of alumni vary widely so that no large number of alumni are of the same mind, usually, on any point. Each alumnus sees his Alma Mater through the spectacles of his own experience. If he has made a success in making spinning tops *that* is the item that should be discussed by the college. Has he made a success in editorial work, then he believes that the most of the technical instruction can well be omitted from the course. Or if he has acquired eminence in scientific work he advocates that nothing but pure science is important to the embryo engineer. Yet out of these conflicting opinions the wise faculty will evolve the changes necessary in the curriculum to make it serve the greatest good to the greatest number.

The second great source of criticism is the opinions of manufacturers and business men who have had occasion to employ young engineers in their enterprises. These men in common with alumni usually contend that the curriculum of the technical schools should be much more specific so as to prepare men to fit quite closely, on graduation, into some special calling. The criticism from this group, however, is likely to be much more narrow than that of the alumni as these critics are less likely to appreciate the value of training in fundamentals and the importance of training men to think abstractly without reference to some special field. Incidentally, criticism of the efficiency of technical schools comes with rather bad grace from this group when one considers the large number of failures of industrial enterprises in this country. Bradstreet reports for January 21, 1911, show that four fifths of such failures are due to causes within the control of those failing, or in other words to incompetence. A technical school that did not do considerably better than this would find itself without students in a short time. If there is a single basic trouble that, more than any other, is rendering the effect of all educational institutions inefficient it is lack of proper financial support, especially in the matter of professorial salaries. If the interest of the business man could be directed to this phase of the problem many or perhaps most of the educational problems would disappear.

Perhaps the greatest weakness in the criticisms that come to the educator from outside sources is their total lack, usually, of a true appreciation of what education is and of what educators are trying to do. Education, if properly conducted, should develop the student mentally, morally and physically. It does not consist, therefore, solely of the presentation of a certain set of facts and there are many imponderables in the problem. The environment, the geographical setting, the ideals of the institution are most powerful; and over and above all close contact with great teachers. These are rarely touched upon by the criticisms of the industrial leader. It is high time that educators paid more attention to these matters themselves and the movement to have a thorough inquiry concerning technical education made by the S. P. E. E. is in the right direction. It should receive the wholehearted support of the teaching fraternity.

DEXTER S. KIMBALL,
Vice-President, S. P. E. E.

ON THE EDUCATION OF ENGINEERS IN FRANCE.

BY A. E. KENNELLY,

Professor of Electrical Engineering, Harvard University and the Massachusetts Institute of Technology.

This report has been prepared on the completion of a most interesting academic year (1921–1922) spent by the writer as first American exchange professor in Engineering and Applied Science, at the Universities and leading technical schools of France, in exchange with M. le Recteur J. Cavalier, of the University of Toulouse, who visited in America the coöperating Universities of Columbia, Cornell, Harvard, Johns Hopkins, Massachusetts Institute of Technology, Pennsylvania and Yale.

The Aim of the Report is to emphasize the differences between the French and American teaching of applied science, leaving aside the very many matters in which the two are alike. If there were no material differences between the French and American training of engineers, there would be little need for, or interest in, a report of this kind. There are, however, numerous differences, attributable, no doubt, to differences of race, history, tradition and custom in the two countries. If these differences in the training can be clearly defined, opinions can be formed as to whether they are fundamental or superficial, important or trivial. There may then be certain features in the education given by one country which the other might desire to adopt. Nevertheless, many of the differences must be looked upon, for the present, as settled and inherent, even if it should be conceded that a change on one side or the other were desirable.

Education in Government Schools.—The first salient difference between the American and French education of engineers

lies in the fact that in America, the engineering schools are nearly all independent and out of government administration; whereas in France, it is just the reverse. The engineering schools are nearly all, directly or indirectly, under government administration. Technical education in France is thus more centralized, systematized and standardized than in America. The French system facilitates the maintenance of uniform standards of scholarship. On the other hand, the American system offers better opportunities for competition and innovation.

Competitive Examinations (*Concours*).—The second salient difference between American and French applied-science schools is found in the conditions for entrance. In America, entrance is primarily by examination, or by certificate based on examination. In general, candidates for entrance to any particular American school are accepted, if they pass the entrance examinations, and the question of the number of candidates who may be allowed to enter in any one year is seldom raised. In France, however, a large number of technical schools have competitive entrance examinations (concours). The examination returns are all placed on one list, in order of rank. If the school has fixed upon accepting say 50 entering students; then only the first 50 names are accepted, even if there should be 1,000 on the list. The successful candidate must therefore not only pass the entrance examination with a certain grade; but he must also reach a sufficiently high grade to bring his name into the first 50 among the examiner's returns. The difficulty of entering thus increases with the number of candidates presenting themselves in a given year. The stiffness of a concours may be defined as the ratio of the competing to the accepted candidates, and it commonly varies from 4 to 10, or from 1 accepted in 4, to 1 accepted in 10. The rejected candidates are usually allowed to try again at the next ensuing examination, probably in the following year.

It seems that, historically, the schools which have competitive entrance examinations nearly all commenced with simple non-competitive examinations, or what may be described as the

American plan. When they came to a condition of prestige and numbers of students that they could no longer find room for all entering candidates taking the standard passing grade, they established the concours, to limit the number of entrances in conformity with their equipment and accommodation. No school having once adopted the concours seems ever to have reverted to the American plan. On the other hand, there have been schools opened in recent years on the American plan which have lately adopted the concours.

Despite the prevalence of the concours or competitive entrance examination, there has been much debate among French engineers as to its merits. On the one hand, the concours overcomes the difficulty of excessive entering students, without having to erect new buildings or equipment for their use. It also provides an intellectual *élite* among the student body, who, by its application, become a picked group of men, able to follow instruction easily and profitably. It likewise establishes a certain prestige for the school in which it is adopted. A school with a stiff concours is likely to regard itself as superior to schools of the same type which have only a mild concours or no concours at all. On the other hand, it is claimed that the concours sets an undue premium upon the passing of entrance examinations, and thus tends to distort the student's view of life; also that it tends, in the building up of a school, to favor that kind of mental aptitude which reveals itself in an acquaintance with books rather than with things; also that it tends to discourage many candidates for entrance who are good students without being brilliant, the discouragement tending to depress, for many years, the activities of the unfortunate rejected.

Engineers and their Classifications.—In the actual conduct of engineering work in France, there are two classes of men who direct operations; namely, (1) Certificated engineers, who have received a diploma in engineering from some engineering school or university institute under government administration. (2) Engineers who have either had no diploma from a government school, or who have only had a diploma from a

state or city manual-training school, but who, through private study or natural ability, have been promoted from the ranks of industrial workers to positions of engineering responsibility. Although there are many brilliant examples of the latter class, yet they must be regarded as exceptions from the standpoint of technical education, and attention will therefore here be mainly directed to class (1), the certificated engineers, and to their training.

Certificated engineers are divisible into two classes:

(*a*) Engineers who have received their diplomas from the state engineering schools, at or near Paris, such as the Ecole Nationale Supérieure des Mines, Ecole Nationale des Ponts et Chaussées, Ecole Centrale des Arts et Manufactures (commonly abbreviated to Ecole Centrale), and the Ecole Supérieure d'Electricité (an independent school maintaining working relations with the State schools). This very important group of professional schools may be called the PARIS SCHOOLS.

(*b*) Engineers who have received their diplomas from the Instituts Techniques des Universités (University Technical Schools). In what follows, these important technical schools, attached to the Faculties of Science of various provincial universities, may be designated as the INSTITUTS.

These two classes (*a*) and (*b*) will be described in detail later.

Preliminary Education of Engineers.—The preliminary education in France is of two kinds; namely:

(1) In Ecoles Primaires, where the tuition is free.

(2) In Ecoles Secondaires, where the tuition is paid by the parents. These secondary schools are called Lycées.

The above two types of preliminary schools are quite distinct and are maintained distinctly throughout France. They are under different administrative departments of the government and the teachers are provided differently. The academic standards are higher and the social corresponding recognition is higher in the Lycées than in the primary schools. Theoreti-

cally, both types of schools prepare their pupils for the universities and upper professional schools; but practically, the great majority of students in engineering professions come from the Lycées. Moreover, numerous state scholarships are offered in the Lycées to promising needy pupils; so that further attention will not here be given to the preliminary training in the free primary and communal schools.

Instruction in the Lycées.—Pupils enter a Lycée at six or seven years of age. There are about 100 Lycées distributed among the cities of France. They are everywhere of the same type and they aim at maintaining the same standards. There are usually four sets of pupils:—boarders, day scholars and two intermediate types. Each large town has at least one Lycée for boys and another for girls. The Lycées were established as state schools in 1802. Under the first empire, their administration assumed a uniform and somewhat military type. The military quality has since disappeared; but vestiges of it may be traced in the summons by roll of drum, still occasionally heard, and in the processional entrances of the pupils, two by two. The head of a Lycée is named a "proviseur." The work at a Lycée is highly systematized. The hours of study are long, and those of recreation and physical exercise short. The teachers are of high grade, drawn either from the Universities or from the Ecole Normale.

On the accompanying *Chart of Distribution*, the line *AB* from the age of 7 to that of 17½, indicates the average course of a pupil directed towards a technical career in applied science. It will be understood that the chart can only give a rough outline of statistical averages; because individual cases so often diverge from the mean. The pupil enters the children's class at *A*, when seven years of age, and after passing through the seventh class at 10½ years, goes on to the Junior Section for four years more. After passing through the third class, at 14½ years, he goes on to the Second Cycle or Senior Section, for two years more. He finishes the work

Chart of Distribution among Technical Schools of French students according to approximate average age. A period of military service, not indicated, must be allowed at the end of each educational career.

of the first class at 16½ and takes his first baccalauréat examination. This corresponds approximately to the end of the high school in American education. Up to this first baccalauréat, the sum of the pupil's age and the number of his Lycée class makes the number 17, approximately. There are no options among the studies of the children's classes. These elementary studies are the same for all. Through the four years of the Junior Section there are two options open; viz.: one with Latin and the other without. In the Senior Section, there are at present four parallel options (Latin-Greek, Latin-Modern Languages, Latin-Science, and Science-Modern Languages). As a rule, pupils heading for technical studies take one of the last two. This scheme has been in operation at the Lycées since 1902; but has not met with general satisfaction. It is now before the French parliament with a view to being simplified. It is believed that the number of parallel options during the Second Cycle or Senior Section is going to be reduced; but no indication of these options is given on the Chart of Distribution; since the outcome is still in doubt.

After passing the first Baccalauréat, the pupil, instead of entering a University or Technical College, as with us, continues for another year at the Lycée, in a class which would claim number 0; but is called by the name "Philosophie et Mathematiques." This class corresponds approximately to our Freshman college year. Pupils heading for a technical career usually select the latter option; that of Mathematiques. The pupil now passes his 2d Baccalauréat at 17½ years, and reaches the point B on the Chart. It is assumed that he has failed no examinations thus far.

The Baccalauréat Examinations which are uniform all over France are (1) written and next (2) oral. The oral examinations are held before a small examining jury of University professors, to which a minority of Lycée professors is usually added. No Lycée professor may, however, put questions to pupils coming from his own Lycée. The second or final Baccalauréat examinations, terminating the curriculum of the Lycée, are at the same time virtual entrance examinations to

the Universities; because pupils passing them successfully have the right of entry into the Universities, after complying with the regular requirements of dues, entrance fees, etc. These features of the preliminary written examination to eliminate obvious failures, followed by an oral examination which is at once a final and an entrance test, are excellent.

Examination Grades are almost invariably counted in France on the basis of 20 as perfection; whereas in America the usual numerical basis is 100 for perfection. This applies to the Collèges (city free schools), Lycées, Universities and Higher Technical Schools, generally. It seems that the scale basis used to be 10, until about a generation ago; when it was found inadequate, and was doubled by common consent. It is probable that no student ever receives the grade of 20, any more than in America he would receive 100. Nevertheless, 19 is occasionally attained. The letters *A, B, C . . . F*, which we so often use, are not employed; but the terms "très bien," "bien," "assez bien" and "passable" are in vogue, corresponding to our terms "excellent," "good," "fair" and "passing grade," or to *A, B, C,* and *D*. Before the French Revolution, degrees and diplomas were couched in Latin, employing the terms "summa cum laude," "magna cum laude," and "cum laude," which we still employ. The rough hand of that Revolution fell heavily, however, upon the use of Latin in public documents; so that at present all University, College and School degrees or diplomas are in laconic French; although the Latin language is more generally and pervasively studied in French academic life than in ours.

Grades below 10 commonly denote failure.

Subsequent Education of Engineers.—After graduating from the Lycée, the youth who desires to study engineering as a profession, must decide between the schools of types (*a*) and (*b*) above mentioned, and as shown on the Distribution Chart. That is to say, he must choose between the PARIS SCHOOLS and the INSTITUTS. A Parisian student will naturally prefer to attempt entrance into the PARIS SCHOOLS; not

only because he lives near them; but also because their prestige is higher. In that case, he enters (at *C* on the Chart) special preparation classes, "mathématiques spéciales," ordinarily in a separate advanced section of a Lycée. In these classes he is drilled in mathematics, also in physics and in chemistry, for passing the competitive entrance examinations or concours of the PARIS SCHOOLS. Ordinarily, he receives no manual or practical training beyond a small amount of duty in the physical and chemical laboratories. After spending a year in these classes, he presents himself for the concours, the stiffness of which may be say from 5 to 10, according to the number of candidates presenting themselves in that year. Not infrequently, he presents himself as a candidate for the entering concours of more than one of the PARIS SCHOOLS. If he is successful, he immediately enters the school of his choice. As a rule, a student prefers to enter the École Polytechnique (*EE'* on the Chart) on account of the importance and prestige of that school in business and social life. More commonly, however, he fails in his first concours and he returns for another year of "mathématiques spéciales." The time spent in these special preparatory classes commonly varies from one to four years. Two years only have been allowed on the Chart, as an average, at *CC'*, which brings him into the PARIS SCHOOLS at the age of 19½. On the other hand, there are considerable numbers of men of college grade in France, who have spent two or more years at "mathématiques spéciales" in unvailing attempts to enter one of the PARIS SCHOOLS. If a student succeeds in passing the concours, he is reasonably sure of securing an engineering position, either in government or in civil service. If he ultimately fails, he must look elsewhere for a professional education.

If the youth who graduates from the Lycée prefers to enter one of the INSTITUTS, his course on the Chart is from *B* to *D*. He selects a provincial university possessing an Institut of the kind he wants. He may be guided in his choice by geographical proximity; or by the reputation of the particular Insti-

tut. There are 17 universities in greater France (Aix-Marseille, Alger, Besançon, Bordeaux, Caen, Clermond-Ferrand, Dijon, Grenoble, Lille, Lyon, Montpellier, Nancy, Paris, Potiers, Rennes, Strasbourg and Toulouse). Not all of these have technical Instituts; but there are a sufficient number to offer a choice. He then presents his baccalauréat diploma to the Faculté des Sciences of the University he selects and applies to enter its Institut of his specialty. As a general rule, there is at present no concours required for entrance. This choice is shown on the Chart at *t*, *u*, *v*, and *w*. The duration of his course is usually 3 years, with regular periodic examinations. On graduation, say at the age of 20½ years, he receives a diploma of Engineer in some specialty of that particular university; such as Ingénieur-Chimiste de Toulouse. There are, however, exceptional instances, in which a concours has to be passed to enter a university Institut (Paris, Nancy), and there may be more in future.

Military Service.—All young Frenchmen are required to pass a certain period in military training. The period has varied in recent years between the limits of 2 and 3 years. The question of reducing it to 1½ years is before the French parliament, and at this date it has not been settled.* The students who enter engineering through the INSTITUTS, (*b*), have to spend the full term of military service at the end of their engineering studies. On the other hand, those who enter by the PARIS SCHOOLS, (*a*), frequently obtain some reduction in their period of compulsory military service. This is obtained by combining a certain amount of military instruction with the regular work of the school. This is especially the case with the Ecole Polytechnique, which is a military school under the administration of the Minister of War. The reduction varies in different cases from half a year to 1½ years. Until the new military service regulations have been issued, these questions remain open to doubt, and no attempt

* Since this report was drawn up, the French parliament has adopted 1½ years as the normal period of military service.

has been made to indicate the additional period of compulsory military training on the Distribution Chart.

There can be no doubt that this compulsory service is a handicap to the technical training of French students. It deters them from spending an extra year in postgraduate advanced studies, such as some of our technical schools give effectively in advanced courses for the Master's degree, and in which good research work is often accomplished. This handicap has been fully admitted by those with whom the matter has been discussed; but is regarded as a regrettable necessity for insuring the safety of the country from much dreaded foreign military aggression. On the other hand, it is pointed out that this period of enforced military service, although always an unwelcome tax upon the productive powers of the young men, has at least the advantage of developing the physique and the working-together spirit of the men, since in the Lycées there has been lack of training in those directions. It is generally admitted, however, that whatever indirect compensation may thus be derived is almost wholly confined to the first six months of military training.

The PARIS SCHOOLS.—No description of French engineering training could be complete without some reference to the great technical schools of Paris. Prominent among these are: (1) the École Polytechnique, (2) the École Nationale des Ponts et Chaussées (roads and bridges), (3) the École Nationale Supérieure des Mines, (4) the École Centrale des Arts et Manufactures, (5) the Ecole Supérieure d'Electricité, (6) the Ecole Supérieure des Postes et Télégraphes. These are all entered by concours, the first section of which is a written examination, and the second an oral examination. The numbers of applicants each year are great. Thus the number of students admitted each year to the École Polytechnique is ordinarily about 250; but the number of applicants is commonly about 2,000. Those who fail either try again the following year or give up the attempt. There are about ten of these Paris Technical Schools.

The Ecole Polytechnique was founded in 1794, under the Revolution. It is very celebrated. Many illustrious scientists have taught in it, and many others have graduated from it. Its diplomas convey academic and social distinction. So relatively few can gain entrance to it, that it becomes a highly selected body of men from the scientific intellectual standpoint. There is a remarkable *esprit de corps* among its students and alumni, which is somewhat unusual in French institutions of learning and resembles the spirit of American universities and colleges. Marshals Foch, Joffre and Fayolle are among its alumni, which include men distinguished in many walks of life.

The school is under the Minister of War. Army officers direct it; although civilians are included on its teaching staff. None can give a lecture before the school without the written consent of the Minister of War. The students are all lodged and boarded at the school. They wear a distinctive uniform. The limits of age entrance are from eighteen to twenty-one. The course of study is the same for all and normally lasts two years, with examinations at the end of each half year. Nearly all who enter pass successfully, at exit, to their diplomas. This is characteristic of the PARIS SCHOOLS. They are very hard to get into; but once in, the student nearly always graduates; whereas with us entrance is not so difficult; but in technical courses, there is usually a heavy mortality in attendance after successive examinations.

In its earlier years, the École Polytechnique taught engineering and especially military engineering; both in theory and in technique. It gave instruction in both the fundamental and the applied sciences. With the progress of the applied sciences during the last 120 years, this rôle soon became impossible to maintain. The school has long ceased to teach applied science and restricts itself to the fundamental sciences. The subjects taught are: Mathematical analysis, geometry, mechanics, chemistry, physics, astronomy and geodesy, architecture, drawing, history and literature, political and

social economy, living languages and military instruction including drill, fencing and gymnasium exercise. The daily routine is military in promptness and precision; but the discipline is less punctilious than at the exclusively military school for Army officers at St. Cyr. The teaching and the scholarship are alike excellent, as might be surmised of a school where both the students and the teachers are so carefully selected.

On graduation, the students are listed in descending order of merit and are allowed to choose the technical school of the service they elect to enter (*f, g, h, . . . m* on the Chart) commencing with the graduate at the head of the list, as far as there are places in those schools available. As these are limited, a student whose name is well down the list cannot expect to enter the State Technical Schools *f* to *k*, and must either take an Officer's commission in the Army, or go into civil life. The usual choice of those who are cut off from the career of Ingénieurs d'Etat, is towards some branch of Military Engineering and a corresponding technical school; but some apply for entrance into other technical schools, such as the École Supérieure d'Electricité, or aim at a business career. It is seldom that a "Polytechnicien" does not find a career open for him!

The École des Ponts et Chaussées is one of the oldest engineering schools in France, antedating the Revolution. It trains civil engineers for the State, in the building of bridges, structures, roads and canals of all kinds. It maintains a three-year course (two years only for Polytechnique graduates). It has always maintained a high standard of instruction. The excellence of the highways in France is attributable to the work of the graduates of this school. It is open to foreign students, but not to women. Entrance is by a stiff concours, except to Polytechnique graduates, who enter directly by their diplomas.

The École des Mines was founded in 1740, and occupies a fine mansion, originally owned by a noble family and overlooking the Luxembourg gardens. The courses of study cover

three years (two years to Polytechnique graduates) and are open to foreigners. There are about 200 students in the school, and about 66 are admitted each year. Entrance is by concours of stiffness 6 to 14. The institution has a famous mineralogical museum and good laboratories, well equipped. During his three-year course, the student spends about 6 months, in two three-month periods, in mines or mining establishments, and makes reports upon the work of the same. This close relation between a technical school and the corresponding industry is comparatively frequent with us; but rare in France. The school has a fine record.

The École Centrale dates from the year 1829. It has a three-year course. The entrance is by concours, of approximate stiffness 8 and the entrance requirements are tending to rise. At present, they correspond at least to those at the beginning of the second year in one of our strong technical schools. The training is towards engineering in general, and the diploma given on graduation (Engineer of Arts and Manufactures) does not distinguish between the branches of engineering; although the students do specialize somewhat in their final year on their projects; but not in their courses, which are the same for all. The students who intend to specialize, for example, in electrical engineering, often, after graduating, spend a year at the École Supérieure d'Electricité. There is laboratory work; but it is secondary to the lecture and class work. There is very little manual training or shopwork. In place of our graduating theses, there are "projects" or designs for plants or machines, accompanied by sets of dimensioned drawings. There are about 700 men in the school, which has long enjoyed a widespread reputation. About 250 students enter annually. Women are admitted; but their numbers are small. Students on vacation are allowed half-rate tickets on the railroads of France. There is an active alumni association which has taken a considerable share in the development of the school. The subjects taught in the third and final year are: Metallurgy of steel, civil

engineering, railroads, mine development, hydraulic plants, aeronautical engineering, electrical engineering (alternating currents), chemical engineering (organic) and accounting. As at the École Polytechnique, each graduating student receives ranking number (rang de sortie), based on the average of his grades throughout the course, in much the same manner as at our Army College at West Point.

There is also an important technical school at Lyon—the École Lyonnaise, with a three-year course.

The École Supérieure d'Electricité dates from 1894. Its inception and development are due to the efforts of its director, M. Paul Janet. The course lasts one academic year, and is a heavy year's work (1st November to 1st August). Entrance is by concours, with exceptions in favor of the graduates of certain schools. The school specializes in the training of electrical engineers. A section has recently been created in Radio-engineering. A number of eminent specialists are connected with the teaching staff. Foreign students are admitted on the basis of degrees or diplomas. There are about 200 students in the school, and about 85 per cent. of those entering have taken their diplomas (Ingénieur électricien). Women are admitted but few actually attend. The laboratories are rather crowded, and are heavily worked. The lecture-room facilities are also overburdened; so that some lectures are given in the Institut Pasteur close by. The school enjoys a high reputation. It has an alumni association (Société Amicale des Anciens Elèves), about 1,000 strong, which publishes a journal or bulletin and holds regular meetings.

(*b*) *Engineering Training at the Universities* (*Instituts*) is a relatively recent undertaking in France, commenced about 25 years ago. The standard French university has four faculties: Letters, Sciences, Law and Medecine (including pharmacy), each presided over by a dean elected by that faculty. The university has at its head a Rector, appointed by the Minister of Education, usually on nomination by the Univer-

sity Council. The rector is not only titular head of the university; but also of the "Academie" of the region in which the university is located, and usually including several Departments of France. An Academie includes all the educational establishments in the region, except the municipal, primary, and certain other elementary schools. Thus the Academy of Toulouse includes the Lycées and other schools of the following Departments: Ariège, Gers, Aveyron, Haute Garonne, Lot, Hautes Pyrénées, Tarn, Tarn et Garonne. All of greater France is divided into 18 Academies. Each rector is nominally responsible for all the secondary and higher education in his Academie. He is aided in this great task by a corps of inspectors who visit the State and Free Schools and by an Academic Council dealing with secondary education, as well as a University Council dealing with higher education. The Faculties of a University are quite independent and their respective professors only meet all together officially on rare occasions. Technical Instituts of a University are placed under the Faculté des Sciences. The administration of the affairs of the Faculty is in the hands of the Dean (Doyen). The staff of an important Institut in the Faculté des Sciences of a University may be composed as follows:

(1) A Directeur (Director).
(2) Professeurs (Professors).
(3) Professeurs adjoints (Associate Professors).
(4) Chargés de Cours and Maîtres de Conférences (Assistant Professors).
(5) Chefs de travaux (Laboratory Instructors).
(6) Assistants (Assistants).

A university receives its budget partly from the government and partly from external resources. These latter may be private endowments or city funds. A university is free, on its own responsibility, to accept gifts, funds or annual payments, from cities, corporations or individuals. A University Council (Conseil de l'Université) will ordinarily include

the Rector, the Deans of the Faculties, certain individual professors, and certain distinguished local citizens; such as the Mayor of the city, the President of the Chamber of Commerce, etc. This infusion of civilian representation on the University Councils is a most valuable recent asset to the provincial universities. It gives them contact with the worlds of industry and commerce, and it also brings them financial and industrial support. The university may thus be enabled to maintain one or more Instituts, for the benefit of local industries; which, in turn, aid and rejuvenate the university. The result is that since 1900, the provincial universities, instead of being mere reduplicates of fixed State higher instruction, happening to find location in different parts of France, tend to become loyal to local enterprise, and scientific supporters of regional industries. The future of the Facultés des Sciences in the provincial universities is thus bright with promise for emulation, differentiation and specialization.

Since French Universities have dates of foundation going back to the middle ages (*e.g.*, Paris *circa* 1100, Toulouse 1229), they have for centuries been enclosed and surrounded by city buildings; so that the newly added Departments and Instituts have usually had to be installed at considerable distances from the main university buildings. In some cities, the various university departments are thus scattered over a dozen or more separated areas. This geographical diffusion tends to keep the different faculties still further apart, and is an unavoidable misfortune; because the mutual intellectual influence of personal contact between members of different faculties in any university is a very precious asset.

Technical Schools or Instituts are at present attached to the following provincial universities: Aix-Marseille, Bordeaux, Grenoble, Lille, Lyon, Nancy, Strasbourg and Toulouse.

Faculté des Sciences de Nancy.—In order to keep the length of this report within reasonable limits, no attempt will be made to describe the Institut of each and all the universities in which technical training is given. It may suffice to refer

to those of Nancy, as a good and typical example. The following Instituts are attached to the Faculté des Sciences at Nancy: (1) Institut Chimique (School of Applied Chemistry), (2) Institut Electrotechnique et de Mécanique appliquée (School of Electrical Engineering and of Mechanical Engineering), (3) École Supérieure de la Metallurgie et de l'Industrie des Mines (Advanced School of Metallurgy and of Mining Engineering), (4) École de Brasserie et de Malterie (School of the Manufactury of Beer and Malt), (5) Institut Agricole (Agricultural School), (6) Institut Colonial (Colonial School), (7) Institut de Géologie appliquée (School of Applied Geology), (8) Institut d'Aerodynamique (School of Aerodynamics), (9) École de Laiterie (School of Milk Industry).

American students who have already received a Bachelor's degree are ordinarily admissible, either to the last year of study in a technical Institut; or to a year of special studies and research, as each case may require. French students ordinarily obtain entrance on presentation of the diploma of the second Baccalauréat. At Nancy, however, certain schools are entered by concours, in addition.

The Academic Year in all the French Universities is the same: viz., from November 1st to July 31st, with one week of vacation at New Year, and two at Easter. In a few of the Instituts the work commences in October. The work of the student is usually over by July 15th. The approximate costs of Institut dues and of minimum living expenses at Nancy are appended.

The Most Advantageous Course for an American student of Engineering to follow at a French University, would ordinarily be a year of special study immediately following his graduation from an American Engineering College with a Bachelor's degree; *i.e.*, after having completed his regular technical courses of study, and before entering engineering or industrial practice. His year of special study in France would then correspond to and replace the year in which he

might ordinarily continue to work for the Master's degree in America. There may be cases in which a student might advantageously spend a year in a French university before having attained to his S.B. or A.B. degree in America; but ordinarily, such a year would not be so beneficial to him; nor would he be in a good condition to benefit by such a break in his studies. A year of special study, corresponding to the year of work for the Master's degree in America might profitably be spent in a French Institut, partly in courses and partly in research or in design. It would lead to a certificate of studies; but probably not to any specific degree. Its advantages would be an intimate acquaintance with French scientific studies, always of a high order, of an enlarged intellectual horizon, and of an increased acquaintance with French engineering, language and literature. The average good American student in applied science can acquire much from a year of postgraduate study in France either in the PARIS SCHOOLS or in the INSTITUTS; but not so much, as a rule, from a year of undergraduate study, owing to the discontinuity and abrupt change of method in his work.

Preliminary Study in France would be necessary for the average American student not well prepared in conversational French, prior to his entering a French university in November, in order to become sufficiently familiar with conversational and lecture-room French. In most cases, this familiarity could be obtained by a student who arrived in France by the end of June, and who set himself to study conversational French in a university town, either with or without entering a Summer-school for foreigners. It is necessary, however, under ordinary conditions, for him to live entirely apart from American companions, from the end of June to the end of October; so as to be compelled continually to listen and speak in French. He should then be quite prepared for university work.

Relative Advantages of the Paris Schools and of the University Instituts.—For American students who have already

completed their technical studies in any branch of engineering or applied science, there would ordinarily be greater advantage in taking a year of advanced work at a provincial university INSTITUT, than at one of the great PARIS SCHOOLS. This is for the reason that such American students are necessarily special students from the French viewpoint. They have had a training different from that of the average French student of applied science. They require special guidance and individual treatment, especially if they undertake research. This special consideration is more readily obtainable from the teaching staff of a University Institut in a Departmental city, than from that of a big technical school in Paris. There is more room for the exceptional treatment of the exceptional case in the provinces. Nevertheless, there may be instances in which the American applied-science student may find his particular needs well met, if he can obtain entrance to the École Centrale, the École Supérieure d'Electricité, or some other celebrated technical school at Paris.

As regards the future development of engineering training, it is evident that France will maintain the existing dual system of PARIS SCHOOLS and of University INSTITUTS. Up to about 1900, the PARIS SCHOOLS offered almost the only avenue for the professional study of applied science. Since that date, the University INSTITUTS have made considerable progress. It is true that they do not enjoy the traditions and prestige of the PARIS SCHOOLS; also their diplomas are not at present regarded as equivalent to those obtained in Paris, owing to the usual absence of a stiff concours for admission, the relatively early age of graduation from them, and the fact that they take in many students who have failed entrance to the École Polytechnique or the École Centrale. Moreover, teachers who attain to celebrity are liable to be called to Paris, which is the Mecca of the French academic world. The provincial INSTITUTS have often lost, in this way, their prominent and influential professors. On the other hand it must be remembered that in order that the teachers should

be desired for transfer to Paris, they must have distinguished themselves by brilliant work in the various provincial Facultés. This takes time. A large share of the French pioneer work in all the sciences comes from the younger men in the provincial universities; so that these contain many of the most vigorous intellectual workers. Again, the PARIS SCHOOLS have, in recent years, shown themselves to be relatively stationary. They have but little room to expand. Their numbers of students and courses of study have not, of late, materially increased. If applied science, and the numbers of its students, in the future, are to increase considerably in France, it would be difficult for the PARIS SCHOOLS to accommodate many more; whereas it would be relatively easier for the provincial Instituts to take them and expand. Consequently, although it is to be hoped that the PARIS SCHOOLS will retain in the future their present influence and prestige, the University INSTITUTS may be hoped to develop greatly and take their full share.

Classroom Conditions.—The intellectual life of French students is severe, both as to the number of hours and as to the quality of work exacted, especially in applied science. Hard work is demanded in the Lycées, Universities and Professional Schools. There is surprisingly little personal contact between the professors and the students everywhere. In the Technical Schools and Instituts, the student rarely consults his professors. He usually comes into closer contact, however, with his teachers in the laboratories and oral examination rooms. These teachers, in many cases, are of lower academic rank than his lecturing professors. Advanced students doing laboratory research work, naturally come into close contact with the professor who directs their task.

The etiquette of relations, in France, between professor and students is more formal than in America. The advent of a professor into a large classroom is frequently heralded by an usher (apparaiteur), and the students invariably rise when the professor enters, retaking their seats when he takes his chair. This was not the custom in America until just

after the return of our armies from France at the close of the war. It commonly happens that University Professors in the Faculty of Law address their classes in academic costume, wearing the gown, but with the cap on the lecture table. The professors in the other faculties only wear their robes on ceremonial occasions; or perhaps at an examination for the Doctorate.

In their lectures, the professors of engineering seldom employ arithmetical examples; although arithmetical examples frequently appear in the problems they assign for solution. They restrict themselves, as a rule, to algebraic expositions; to the abstract general case, rather than to the concrete example. On the other hand, their lectures are very clear, precise and systematic. The students are nearly always well grounded in theory, and can follow algebraical demonstrations at the blackboard with facility. This is especially the case in the Paris Technical Schools. The students like to see an analytical presentation of a technical subject, and are captivated by an artistic demonstration of a proposition in classical form. In these directions of intellectual training, the French student, on the average, is ahead of the American student. On the other hand, the average French student of engineering is less capable with his hands than the American student (except in draughtmanship) and he has a less keen sense of economic and financial proportions in design. If the French student goes through the regular École-Polytechnique curriculum, he spends so much time on theoretical preparation and so little on manual training, laboratory work, or contact with machinery, that by the time he graduates, he is apt to be much ahead of the American graduate in fundamental scientific training; but much behind in practical capability of directing production or engineering undertakings; so that he is in danger of drifting into positions of administrative routine.

Advantage of the Metric System in French Training.—The French teaching of engineering has the systematic advan-

tage that nearly all the units of measure which it employs are the same as those in the fundamental sciences, and are in the simple international metric system of the meter and the gram. In our American teaching, the fundamental sciences chemistry and physics are usually taught in the units of the metric system; while statics, dynamics and mechanics are not. Moreover, nearly all of our engineering and applied science (with the exception of electrical engineering) are taught in our complicated and cumbersome non-metric units. This gives the French applied-science schools a considerable advantage over ours, in simplicity of exposition and in clarity of quantitative statement. Both English and American engineering text-books suffer disparagement in the opinion of French students, who cannot readily understand their units, or how such practical peoples can continue to use such clumsy tools of nomenclature, reasoning and calculation.

Student Activities and Social Relations.—French students have many fewer personal relations and coöperative activities than American students. As a rule, they rarely meet outside of their classrooms. The class spirit is but little developed. Their allegiance to their alma mater is less marked than in America. Technical-school or university life seems to produce, in advance, the formally polite but competitive behavior of later professional life. Nevertheless, some of the PARIS SCHOOLS have Alumni Associations (Associations Amicales des Anciens Elèves), which hold meetings, dinners and reunions. The students of Paris, including the Université de Paris, the Collège de France, and a number of Technical Schools, have an "Association des Etudiants de Paris." The Section des Sciences of this Association publishes a monthly Bulletin Scientifique. Certain INSTITUTS at the Universities of Nancy, Grenoble and Toulouse have similar Alumni Associations. It would seem that laboratory work tends to promote closer social relations between the students than classroom study. Where a student restaurant is operated under

university auspices, there is also fostered a certain degree of social coöperation and *esprit de corps.*

Academic Degrees Open to American Students.—Practically the only degree open to American students in France is that of "Docteur de l' Université" which corresponds to the American Doctor of Philosophy, or Doctor of Science. It is obtainable in the Facultés des Sciences of the Universities by well-qualified American students presenting a Bachelor's degree in compliance with certain clearly specified regulations. It is seldom that such a degree will be aimed at by American students of applied science and the Doctorate degree in Engineering is most rare in France. On the other hand, the American graduate student who should spend a good academic year of work in a French technical school, could undoubtedly obtain, on its completion, a certificate of study, which might well be regarded in America as equivalent to a Master-of-Science degree.

Research in French Engineering Schools is little known. Some professors carry on research in their laboratories, with or without the aid of students, and doubtless many more would do so, if students came forward offering to undertake research, as they often do in America. The regular courses of French engineering study in some of the PARIS SCHOOLS and in some of the University INSTITUTS, call for design theses (projets) or studies of existing plants. They hardly ever call for experimental research theses. After his technical course is completed, and his diploma obtained, the French engineering student usually considers that he must at once take up his impending military service, and then enter on his life work. Indeed, many men fail to enter their career before twenty-five or twenty-six years of age. Consequently, there is relatively little opportunity for postgraduate study or investigation. If, however, a student who had already graduated from an American technical school under satisfactory conditions, should present himself for a year of postgraduate technical work in France, he could doubtless under-

take either design or technical research, under the direction of French professors in his specialty. The laboratory equipment for technical experimental research existing in the French schools is often limited, in comparison with that existing in the strong American schools; but the teachers, as a rule, have so much ability, that the defects in material can ordinarily be compensated for or overcome.

Conclusions.—The French system of training in engineering professions is usually superior to the American system, in its systematic qualities, and especially in its thorough grounding on the fundamental sciences. It is usually inferior to the American system on the practical sides of manual training, laboratory equipment, economic training and relations with industry. The French student life is more methodical and more laborious intellectually; but is less socially and athletically developed. In technical research and post-graduate studies of investigation, the American facilities and opportunities in our best technical colleges are superior. In France, the idea of "applied science" throws emphasis on the word *science.* In America, it throws emphasis on the word *applied.* The optimum desideratum probably lies between the two. Each country has, therefore, certain advantageous features in technical training to offer to the other, and an exchange of graduate students for a year of special studies should not only prove most advantageous to them; but also offer the best channel for enabling mutual benefits in training to be readily absorbed.

The Institutions which are able to furnish Information to students seeking opportunities to realize these advantages are:

In New York, The Institute of International Education, 419 West 117th St., and The New York Branch of The *Office National des Universités et Ecoles Françaises,* 1834 Broadway (Columbus Circle),

In Paris, The *Office National des Universités et Ecoles Françaises,* 96 Boulevard Raspail (VIe),

and The American University Union, 1 rue de Fleurus (VIe).

This Union is supported and controlled by some fifty of the American leading Universities and Colleges. It entered on its register during the year ending March 15, 1922, a total number of 1,348 American students studying in France (716 men and 632 women), of whom 817 were working in Paris and 279 at Provincial Universities. These students were distributed among 49 different French institutions, not including Lycées or private schools. They represented 174 American universities, colleges or technical schools. Comparatively few of them were in engineering.

Engineering Subordinate Training.—Although the professional title of Engineer in France is considered as ordinarily designating the holder of a diploma either from the PARIS SCHOOLS or from an INSTITUT, yet there are certain important technical schools of lower rank which aim primarily to train for superintendents and foremen in engineering establishments, and in which the teaching is less theoretical and more practical. The most advanced students graduating from some of these schools receive diplomas as engineers. Although these schools have a lower prestige, they have the advantages of closer contact with the industries, and their graduates are qualified to direct in person various engineering enterprises. The academic level in these schools is much below that of the Instituts or Paris Schools; but the graduates are well trained practically and fitted for production.

Prominent schools of this type are:

(*a*) The Écoles Nationales d'Arts et Métiers, at Aix, Angers, Châlons-sur-Marne, Cluny, Lille and Paris. The Paris School is the strongest and best known. They have long been in existence (except the Paris School, which is more recent) and are under government administration. They give a normal three-year course, but the Paris school offers a fourth year in special directions. The age of entrance is ordinarily sixteen to nineteen. The entrance is by concours

of stiffness about 4. The first part of the concours is a written examination, and those who pass, present themselves at the school for the second and oral examination. Each school has about 100 students. Only a small percentage have taken a baccalaureate diploma and only a few have attended the Lycées. Nearly all have passed through the Écoles Primaires, (and Écoles Primaires Supérieures) or free-tuition schools. Nevertheless, owing probably to the selective influence of the concours, the work of the students is usually very good, and relatively few of those who enter, fail to obtain a satisfactory graduation mark. The course includes some study of modern language, geography, history, mathematics, mechanics, mechanical drawing, physics, chemistry and accounting. The school year is from October 4th to July 13th, with the usual holidays at New Year and Easter. Morning hours (8 to 12) are given to classroom studies, and afternoons (13 to 18) to the workshops, where manual training is given very effectively. The principal shops are for assembly, forging, pattern-making and foundry practice. The students graduating, usually about the age of twenty, readily find places as workmen in industry, and often subsequently work up into engineering duties.

(*b*) The École Spéciale des Travaux Publics, at Paris and at Arcueil in the suburbs, is a technical school, started in 1891, and now coördinated with the system of State instruction, although an independent establishment. Its primary object is to train foremen and superintendents of public works; but it also aims to give engineering training up to a certain standard. In addition, it carries on a large correspondence school. Entrance to the school is by annual concours of approximate stiffness 3, at the average age of sixteen. The practical work is conducted at a large establishment near Arcueil-Cachan, a few kilometers south of Paris; where about 1,200 students are enrolled, 150 of whom are permanent boarders. The courses last from one to three years. During the mornings, there is classroom work. The remainder of

the day is spent in draughting rooms, laboratories and workshops. This is stated to be the only technical school in France giving practical instruction in public works. The upper classes find morning work in Paris, and afternoon practical work at Arcueil. The correspondence school offers instruction in about fifty different programmes, by mail, in a manner broadly similar to that followed by American correspondence schools. In 1920, nearly 25,000 pupils were registered in the correspondence school, and the alumni association included 8,000 names.

Industrial Trade Schools.—Of a still lower academic grade, but yet of great industrial importance, are the various industrial trade schools, supplying trained young men for production. A good example of these is the École Diderot at Paris, founded by the city in 1873, for the training of foremen in various manufacturing plants. The pupils enter by a concours of about stiffness 8, each year. The entering age is from thirteen to seventeen. The course normally lasts three years. The number entering each year is 120, and the total number in the school is about 350. The effect of the highly selective concours is to produce a picked body of pupils, the great majority of whom receive a diploma at the end of their course and are much sought after in the industries. Pupils from the Paris district pay no tuition; but those entering from other districts pay a tuition fee. The subjects taught are: Forging, Metal Work, Assembling, Instrument Work, Electrical Work, Wood-turning, Furnace Work, Blacksmithy and Pattern-making. There are 12 shops, each with an instructor and about 30 pupils, 10 to each year. A pupil is assigned to one and only one shop, in compliance, as far as possible, with his choice. The pupils receive elementary instruction in morning classes. The hours are from 7.45 to 12, and from 13 to 17.45. The pupils ordinarily take their noon lunch in the establishment.

There are nearly 200 Trade Schools in France.

In conclusion, the author desires to express his indebtedness to many of his esteemed colleagues and friends in France,

for their kind help in ascertaining many technical particulars set forth in this report. He has endeavored to make this expression in more proper form, and at greater length, in a separate personal report to the coöperating American universities.

Appendix

Estimated Expenses for an American Student in Residence at the University of Nancy during the Academic Year

The following are minimum estimates of expenses derived from data received at Nancy, considered as a representative university, in which an American student might study at an Institut under the Faculty of Sciences. American students who have already received a Bachelor's degree are ordinarily admissible, either to the last year of studies in an Institut of his specialty, or to a year of special studies including research or design, as each case might require. The regular dues for tuition during the academic year are stated to be 1,200 francs in most cases. In certain Instituts it is less. In addition, there are certain moderate fees for registration, library and laboratories.

Living expenses during the 8½ months of the working academic year (3d November to 14th July), assuming that the student remains in residence during the Christmas and Easter vacations (10 days at Christmas, and 15 at Easter):

Room and service	650	francs	(paper)
Heating	150	”	
Lighting	80	”	
Premier déjeuner	130	”	
Two meals daily, at University rsetaurant	1300	”	
Pourboire Fees for restaurant	90	”	
Total	2400	”	”

or at the rate of exchange of 11 francs to the dollar, approximately 220 dollars total or 26 dollars per month. To this must be added expenses for laundry, clothes, tramways, tea, tobacco and amusements, which will vary in every case. The above items have been quoted as *minimum prices under Uni-*

versity lodging conditions only. Board and lodging costs in the town of Nancy will average considerably higher than the above. Travelling expenses must also be added.

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COMMENT ON REPORT OF DEVELOPMENT COMMITTEE.

Letter to Deans or Presidents of Engineering Schools.

October 2, 1922.

My dear .....

The Society for the Promotion of Engineering Education at its annual convention in June took action looking towards expanding its service to engineering schools.

Our modern life is increasingly dependent upon engineering and demands men of engineering training not only for technical and professional service but for leadership in industry and in civic life. In view of these larger opportunities and responsibilities of the engineer, it seemed fitting that the Society should undertake, in a broader and in a more comprehensive way than it has done in the past, the development of the training of the engineer. The outcome was the appointment of a committee to consider "What can the Society do in a comprehensive way to develop, broaden and enrich engineering education?" The Committee's report,* which has been endorsed by the Council, contemplates a Board for Investigation of the facts relating to engineering education and the general coördination of the activities of all those concerned with the training of the engineer. The Committee recognized that the schools themselves should be very active participants in the proposed movement which should, in a large measure, be one of the schools, by the schools and for the schools. The Board can coördinate what is being done and aid in planning for the future.

I am asking counsel and suggestion from the engineering schools for the guidance of the Board in laying out the work to be done. Many of the schools have been making a study of the situation, to determine how their training may better prepare their graduates for the demands of the future. The present, however, is a time for coöperation and combined effort and while there is much for each college to do individually there is more to be done in common for the benefit of the country as a whole.

The Society, with over 1,500 individual members and 86 institutional members, places itself as the agent of all concerned with engineering education and invites the coöperation and assistance of all.

You are requested to give the Board the benefit of your experience and counsel in making definite plans for carrying out the general intent of the report of the Development Committee, copy of which is attached.

* See Engineering Education, Sept., 1922.

ABSTRACT OF REPLIES TO LETTER.

What are the really important things to be done and what is the best method of procedure? To what features of the general problem has your school been giving special attention? What may it in the future plan both for itself and as a contribution to the general movement? Replies from individuals and especially from faculties will be helpful. Communications received by the middle of October will be doubly serviceable as they can be presented to the Board at its first meeting.

Very truly yours,

CHAS. F. SCOTT,

President, S. P. E. E.

EXTRACTS FROM REPLIES TO ABOVE LETTER.

J. R. BENTON, Dean, College of Engineering, University of Florida.

"I have read with a great deal of interest your letter of Oct. 2 and the Report of the Development Committee. The announced plans of this committee appeal to me so strongly that I have nothing to criticise and nothing to add, and my only comments would be on the placing of emphasis. I would be most interested in the fundamental inquiry as to what the engineer graduate should be and that under the head 'To ascertain present and future requirements in the fields served by engineer graduates.'

"I have often thought it would be very helpful if we had better information as to the probable number of engineers of various kinds who will be needed in the industries of the future.

"I give hearty approval to the proposal that the Director of the Development Committee should visit Engineering Schools and meet both teachers and students."

ALEXANDER C. HUMPHREYS, President, Stevens Institute of Technology.

"Of course, there is room for improvement in the line of engineering education. To be frank, I think the results will more than usually depend upon the Committee and I see you have got good men on that Committee with yourself as Chairman.

"In your letter you say, 'To what features of the general problem has your school been giving special attention?' We have not been giving 'special' attention to anything. We have been trying to work along just the other line.

"We have also been very careful in the face of considerable pressure at times to maintain the balance between the curriculum responsibilities and the extra curriculum activities, and of the latter, especially athletics.

"It would be a great thing if this Committee could work up something of real value to the country and I think it would be an excellent thing for the S. P. E. E., for I confess the Society to my mind has failed in many directions, although I fully recognize that you have been a great force towards improvement."

FREDERICK W. ATKINSON, President, The Polytechnic Institute, Brooklyn.

"Your letter of October 2 strikes a responsive chord in my mind. At the first meeting of instructing corps this year I discussed many of the points touched upon in your letter and attempted to bring out clearly the changed conditions facing the technical schools and the need of the thorough revision of their courses with a view of bringing about a closer coördination both with the industries and with all of our civic institutions.

"A few of the subjects that I have appointed a special committee on Educational Policy to discuss here are the following:

"(1) How may we better assure ourselves that every single student is thoroughly trained in the fundamental principles? Is it not true that so much is attempted in the first two years that there is not time for thorough outside preparation in these fundamental subjects? Should not, for example, less time be given to drafting now that we know none of our graduates will be draftsmen? Should not in the Civil Engineering Department less time be given surveying because we know none of our graduates will be surveyors? Our first year is a common year for all students. Should not the first two years be the same for all students?

"(2) Is there not too much specialization the last two years? Is it perhaps desirable in these years to have optional technical subjects? (In Civil Engineering with us Water Supply, Highway Engineering, Bridge Design and Structures are required for all students.)

"(3) What plans are practicable for enriching and broadening our courses, assuming always that there will be time for a thorough training in the fundamentals.

Are not the professors who represent the simple engineering subjects requiring too much in too many subjects? Are they not defeating their own ends? Would not a better procedure be to have thorough subjects better taught with plenty of time for outside preparation by the students? Could we not by teaching thorough subjects well make possible intensive thought and study and by not attempting a superficial and too great field of intensive study make room for a considerable range of electives in cultural subjects?

"(4) It is my observation extending over a period of eighteen years that not enough attention is paid to the work required by the thesis. I believe that each student independently guided by his professor should make a special and thorough investigation of a small original problem, the results to be embodied in a thesis. I believe that one third of the seniors' time might well be devoted to this.

"This will give a little idea of what we are attempting here. Let me assure you of our heartiest coöperation in your purpose and our willingness to be represented at any meeting at which this is discussed. Professor Harry P. Hammond is the Chairman of our Committee on Educational Policy. If you wish to hear from him directly I will have him write you."

(In full.)

HUGH MILLER, Acting Dean, George Washington University.

"First: The important things to be done are (a) to liberalize the curriculum, probably making the degree B.S. in Engineering instead of B.S. in the several branches, (b) to raise the standard of teaching by better selection and training of teachers, (c) to coöperate with industry by research, consulting work by older members of the faculty and part time employment of students.

"Second: We are trying to liberalize our curriculum adding postgraduate courses and raising salaries.

"Third: We aim to increase laboratory facilities so as to provide for research work."

JOHN B. WHITEHEAD, Dean, The Johns Hopkins University, Baltimore.

"I find myself somewhat uncertain as to how to write you because I feel that concrete suggestion is really what

you want. Nevertheless the report of the development committee suggests such a wide range of subjects, and your own letter is so cordial and broad in the opportunity which it offers for comment, that I feel that I shall probably be discussing education itself rather than confining myself to thoughts on definite measures of procedure. I shall, therefore, venture to follow the sequence of topics as they arise in your own letter.

"I concur heartily that the schools themselves should be very active in the proposed movement.

"We have had the benefit of much comment and criticism from the ranks of industry. My own opinion is that we have been paying too much attention to these comments.

"On the other hand, I believe that there is grave danger in relying in too great a measure on the schools themselves.

"In other words it is my feeling that the operation of your Board and Council should in some way provide for giving practical weight to the opinions of, let us say, the elite in both the industry and amongst the schools.

"In thinking over what I have written above I realize that I am suggesting a course which is hardly consistent with the Democratic ideals of our country, our Society, and its President.

"Your letter also asks for something from our experience and thought as to the general problem. Although we are only ten (10) years old, and, therefore, perhaps the youngest of engineering schools, it is nevertheless possible within ten years to obtain a valuable survey, particularly when our plan at the start was the result of a very close study of conditions then obtaining. We like to feel that we were among the leaders in the present reaction from the highly specialized laboratory and curriculum, towards broader courses aiming to give the student a wide point of view and a general rather than a special professional training. To this end our plan at the start was (2) years of general underlying and scientific subjects; engineering subjects introduced only in the third year and then only of a general character in all fields, and with specialization limited practically to the fourth year. Further specialization is placed in graduate work. This is still our plan, and I have no hesitancy in saying that I believe

that it is the most satisfactory for a four (4) years' course. Our senior students absorb very rapidly and are able to cover far more ground than we expected. We attribute this to the character of the earlier work. The success of our graduates and the warm endorsement that we receive from those employing them bear out our feeling.

"In connection with the foregoing plan, its general adoption should ultimately result in relieving engineering schools of the first two (2) years as a necessary part of their duty. For example, if two (2) years of college work were required for admission to the engineering schools this would mean placing the school of engineering on a definite professional basis. I believe that this would be going very far toward improving the status of the profession of engineering both in our universities and in the eyes of the public. There is, of course, nothing new in this suggestion, but I believe that your Board would do well to investigate conditions in the schools as regards both teaching and physical equipment. This appeals to me strongly provided that the results of this study may be generally known. As already suggested I feel that we are suffering from the intermingling of the better class of schools with those of a vocational character and those of inferior standing. I do not feel that the school which caters directly to the more mechanical operations of manufacture and industry should be classed as a professional school, but I favor strongly the public recognition of two (2) types of engineering graduates; namely, the vocational, which we might say would be the result of two years of engineering-school training, and the professional, resulting from one or more further years with appropriate special degrees.

"If the Board and Council should reach a conclusion that their purposes would be furthered by some such modifications of existing methods as is suggested above it occurs to me that it would not be a difficult matter to secure the concurrence of a selected group of our leading schools who would agree to put the plans into effect. I believe that this would result in the falling into line of all other schools able to do so, and in the automatic separation of others now in the vocational class.

"In the above I have said nothing about the graduate school and the possibility of more activity in the field of research. We give considerable attention to this field

here. We regard it as most important, not only for such contributions as we are able to make to the profession, but also for the reaction on the spirit and morale of our teaching staff."

H. J. HUGHES, Dean, The Harvard Engineering School, Harvard University, Cambridge, Mass.

"(1) To develop high ideals of engineering education, not only in the colleges but in the secondary schools, in both students and teachers, and

"(2) In order to develop and put into effect high ideals in education we must have a thorough understanding between the schools on the one hand and the industries and other employers of engineering students on the other, as to what is the proper function of the schools and what part of a student's education must be provided by employers either during vacation time or after the student graduates.

"The features of the general problem to which this school has given special attention are the following:

"The building up of a high-class teaching force.

"The enforcement of high standards in the selection of students from secondary schools, and of transfer from other institutions.

"The rigorous elimination of low-grade students and care in the award of degrees.

"A systematic attempt to get into close touch with the industries not only by establishing industrial cooperation for our students during part of their undergraduate period, but also by frequent meetings with the men in charge of the nearby industries.

"And in order to prepare our students for business as well as engineering we have established five-year programs combining engineering and business which are conducted jointly by the Engineering School and the School of Business Administration, these courses being planned to give our engineers a considerable training in business administration without sacrificing either the rigorous training or any of the important subject-matter of our four-year engineering course.

"Our first aim always will be to secure the best teachers possible, to improve our means of selecting and eliminating students, and to increase our contact with the leaders of industry. As a school we shall always be interested

in, and ready to coöperate in, any movement which tends to improve engineering education. I do not believe, however, that our Faculty will be likely to favor in general any attempt at standardization of education. There are various ways of attaining the objects we all desire, and what may be the best arrangement in one place may not work as effectively elsewhere.

"For my own part I hope that in time our engineering schools will not only have more rigorous and more intelligent tests for admission from the secondary schools, but also more general examinations during the college course, for I think that the engineering schools as well as some of the colleges are overdoing the tabloid method of instruction. I believe there ought at least to be a general examination for admission to the Third Year, which should cover mathematics, chemistry, physics, and perhaps some mechanics, and that there also ought to be a general examination before graduation which will test both the student's knowledge and his ability to think. And I think these examinations should, in general, cover about the same fundamental subject-matter in all schools.

"I hope this new Board will not attempt the collection and compilation of large volumes of statistics, for they are likely to be of little value in comparison with the expense and labor necessary to compile them.

"As I visualize the real function of this Board, its objects should be to educate the teachers, students, parents, the general public, and the future employers to a proper understanding of what a real education means. If the Board can accomplish this, the details will be comparatively easy."

ARTHUR M. GREENE, JR. Dean and Professor of Mechanical Engineering, John C. Green School of Engineering, Princeton University.

"*We all stand ready to work* with the organization which the report contemplates.

"The Princeton idea is that our students should have *a thorough fundamental training* on which to build a limited amount of engineering education in college and a great deal of engineering development after graduation. We plan to give four years for the undergraduate course leading to the degree of Bachelor of Science in Engineering, in which a large part of the time will be devoted to

fundamental science, history, language and literature, and I hope, philosophy and psychology. The required work in economics will cover four terms. This is to be followed, by those who can stay, with one year of engineering work together with economics. We believe that by this arrangement men can be trained to be leaders and be of great service to the profession and to the community."

G. W. BISSELL, Dean of Engineering, Michigan Agricultural College.

"At this school we have tried to improve our courses in the light of suggestions made from various sources, and our latest development is providing that engineering students who so desire *may elect* in the last two years, one quarter of their work in a series of subjects, which for the want of a better name we have designated as *Engineering Administration.* I am enclosing an outline of this new course which is made effective for Sophomores and Juniors this year.

"This present Junior class is divided in proportion of sixty per cent. Engineering Administration and forty per cent. regular technical course.

"Engineering courses should be characterized more and more by greater *emphasis on fundamental sciences* and English, history, economics and a correspondingly lessened emphasis should be placed upon technical-informational subjects.

"I feel, however, that progress in this direction must necessarily be slow until the preparatory schools coöperate."

KARL O. THOMPSON, Secretary of the Faculty, Case School of Applied Science.

"The faculty of Case School of Applied Science has considered very carefully the recommendations of the joint committee of the Society for the Promotion of Engineering Education concerning the creation of a Board of Investigation and Coördination.

"We wish to assure you of our hearty accord with the proposals of this joint committee and that we will do all in our power to help carry them out."

(In full.)

R. L. SACKETT, Dean of Engineering, The Pennsylvania State College.

"Your energy and perseverence deserve a prompt response and such encouragement as any can offer.

"The program provided by the development committee is so extensive and so courageous that one's hopes rise.

"In my judgment the first question is, what are the facts? What are the statistics of college technical graduates? Are they measuring up to present demands on engineers or not? We have no accepted measure of success or of production by college technical graduates and probably could not agree on one.

"The committee report under 'A' asks, 'What the engineer should be?' Equally important is the question 'What *is* he?' What are the causes for the difference between what he should be and what he is?

"B 'What the training of the engineer student should be and the influence surrounding him' is the constructive feature of the program and a mighty one. It is the theology of the whole matter. No particular curriculum can be the orthodox and all others heterodox. We need a variety of technical schools because no particular group of courses or curricula can prepare all the various kinds of engineers which this highly specialized age needs. In my judgment, specialization is a matter for the school of experience and for post-graduate study to supply. The young engineer needs a more thorough grasp of the fundamental tools and of the foundation ideals of all engineering.

"A Board of Investigation might perform a most valuable service. Research is needed before formulating a program.

"Why cannot the U. S. Bureau of Education do some investigating? Has any inquiry been made? Is it subsidizing other movements of an educational character of less importance, such as 'Commercial Engineering'?

"The report is *good* although in spots it sounds like an attempt at the creation of a 'closed shop' in education and standardization of product. That is not what the Committee means and it would do no good and little harm even if it did. The 'objects' in par. VI are especially fine and reflect the real purpose and high mind of the Committee."

(In full.)

Jos. F. MERRILL, Director, School of Mines and Engineering, University of Utah.

"The first monthly meeting of our engineering faculty occurs October 23d. Your letter and other matters pertaining to S. P. E. E. will be presented to that meeting.

"Three suggestions I make on my own responsibility:

"1. Let the Society *grade the engineering schools* of the country into classes A, B, C, naming the requirements of class A rating, etc.

"2. *Help instructors of engineering students to become better teachers.*

"3. Make the Society nation-wide.

"Engineering education in the Great West would be helped if our Society would hold its annual meetings out there occasionally. It would be contrary to Nature if the reaction would not help our Society."

A. A. POTTER, Dean of Engineering, Purdue University, Lafayette, Ind.

"I am appointing today a committee consisting of Professors Harding, Wiley and Munro, of this institution, to study your letter and to let me have definite suggestions for transmittal to you. I hope that the committee can be of some service to you."

G. M. BUTLER, Dean and Director, The College of Mines and Engineering and Arizona Bureau of Mines, University of Arizona.

"This report I have read with a *great deal of interest* and a *considerable measure of approval.* Such an investigation as has been outlined is going to cost a considerable amount of money, but, if the necessary funds can be obtained, it is more than possible that an investigation of the nature suggested would prove decidedly beneficial. I foresee that the task is going to be a long and arduous one, however, if the results are to be useful. It has been my experience that employers of engineers, engineering graduates, and engineering educators all hold more or less decidedly contrasting views on engineering education.

"Many of us have spent twenty or thirty years investigating and considering these questions, and have devoted a large portion of our time to these problems. It is therefore going to take some very strong evidence collected by men in whom we have implicit confidence and distributed

over a relatively long period of time to convince us that our conclusions are wrong. It is also going to be necessary for the Board of Investigation and Coördination and the Board of Councillors to interview hundreds or perhaps thousands of people before they can be sure their conclusions represent average opinions.

"Even if the work is carried on by such people as I have suggested and in the way outlined, I doubt if *we can expect that engineering education will become standardized.* In fact, I am not at all sure that it is desirable to standardize it. Each school should aim to meet the *needs of the people who support it,* and these needs vary in different parts of the country. Some schools should emphasize undergraduate, and others, graduate work. Some schools should attempt to produce executives, while others should emphasize technical training.

"While the Society will doubtless obtain a great deal of interesting information as a result of the program outlined in the report of the Development Committee, I do not believe that the conclusions reached will radically affect engineering education as at present conducted, any more than was done by the Mann Report.

"I am inclined to think that the ideas of intelligent graduates who have been out of school for several years and the successes enjoyed by such men are the best guides that I could have.

"The work which the Society proposes to undertake *interests me very much indeed.*"

HENRY B. WILSON, Rear-Admiral, U. S. Navy, Superintendent United States Naval Academy, Annapolis, Md.

"I agree fully as to the great place occupied by Engineering in the world today, and the even greater place to be occupied in the future.

"Technical and engineering schools can no more turn out the finished engineer than law or medical schools can turn out finished lawyers or doctors. The best that can be hoped for is that, during the student career, a suitable foundation can be laid, with perhaps a framework on which, in the post-graduate school of experience, the completed structure may be erected. The same is true of the Naval Academy in turning out Naval Officers.

"Thus it seems to me that the great study of the Board is to find out—first, in what respects the engineer-

ing graduates fall short, either in their training or in their number of industrial requirements; and second, in what way these deficiencies can be made up by an alteration of the courses at the engineering schools, or by inducing students to choose this or the other branch of engineering."

WILLIAM M. THORNTON, Dean, Department of Engineering, University of Virginia.

"The subjoined report, arrived at after full conference by our technical staff, was formulated by a committee appointed for the purpose and expresses our matured view that the fruitful field for study will be the Industries and not the Colleges.

"We have received the report of the Development Committee to the members of the Council of the Society for the Promotion of Engineering Education, and have read it with interest. We *sympathize* with the purposes in the minds of the members of the committee, and desire to coöperate with the committee.

"We believe that the most profitable first study would be *the present and future needs of the industries.*

"It is our opinion that this study can be made best by engineers who are members of *the industrial organizations* rather than by visiting committees, and, therefore, suggest:

"First. That the industries should agree to employ competent *young engineering teachers* for a sufficient period of time to enable these teachers to study thoroughly the needs of the industries. These teachers should have conferences with each other, and round table discussions from time to time.

"Second. That the Engineering Colleges be asked to inaugurate a plan by which *their graduates in the industries will make definite reports,* from time to time, on the needs of the industries and suggestions for changes in the curriculum to meet these needs.

"(Newcomb, Hancock, Rodman—Committee) I forward it with cordial approval as the result of our experience in acquiring information as well as of our reflections upon your problem."

(In full.)

GEORGE B. PEGRAM, Dean, School of Mines, Engineering and Chemistry, Columbia University.

"The questions asked in your circular letter of October 2, accompanying a copy of the report of the Development Committee, are too broad for me to attempt any general answer to them. I am *highly in favor of the S. P. E. E. causing a general inquiry to be made,* through its own agencies or by as wide a range of coöperation as necessary into the two fundamental points mentioned in the report of the Development Committee, namely, *What should the engineer graduate be,* and what should the *training of the engineer student and the influences surrounding him be.* The feature of such an inquiry that seems to me most deserving of full attention just at present is a study of the number of engineering graduates *of different kinds and degrees* of education which can with economy in the broadest sense be utilized by the community at large. For example, how many mining engineering graduates will be needed in the next five or ten years?

"The same question with relation to medical education has been getting a good deal of attention, and the case is a much simpler one because the number of physicians needed to serve the community is in fairly direct ratio to the population, while in engineering the situation is obviously much more complex. I suspect that there would be a *wide gap between* the number of engineer graduates that are *actually being utilized* by the industries and the number that could with *advantage to the industries be utilized.* A proper survey might well be the means of stimulating a far greater demand for engineering graduates than has existed before.

"In answer to your question 'To what features of the general problem has your school been giving special attention?' I can say that naturally our special interest in engineering students at Columbia is directed towards those men who elect to study engineering as they would law or medicine, after a preliminary undergraduate college course.

"As indicating further what I might say on this general subject, I am enclosing copy of some paragraphs from my last annual report as dean of the engineering school here."

ABSTRACT OF REPLIES TO LETTER.

EXTRACT FROM ANNUAL REPORT, JUNE 30, 1922, OF THE DEAN OF THE SCHOOLS OF MINES, ENGINEERING AND CHEMISTRY, COLUMBIA UNIVERSITY.

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The enormous expansion of some industries, the realignment of others, and the many entirely new undertakings made necessary by the war, as well as the rearrangements necessary immediately after the war, caused an abnormal and unprecedented demand for engineers. The enrollment of students in engineering schools reflected this demand with the result that in the past two years of business depression the supply of men with engineering training has exceeded the demand for their services . . . but the situation as a whole is one to cause concern to all who are interested in engineering and engineering education. An approximate answer to the question "How many engineering-school graduates are needed annually?" would have a most important effect on engineering education. The education of the engineer is greatly discussed from the qualitative standpoint, but very little has been done on the quantitative side. Are too many young men taking up the study of engineering, too few, or is the number about right? The question is certainly not to be answered so definitely as in the case of medical education, for the number of physicians that are necessary to serve the community is in pretty definite ratio to the population, and the medical schools of the country have realized the wastefulness of providing an expensive medical education at the cost of the general public for every young man who thinks he would like to be a doctor. Fairly close selection of students to whom a medical education is given is now being made on the basis of pre-medical college records. Furthermore, the question as to engineers cannot be answered without taking full account, qualitatively and quantitatively, of the various types and amounts of engineering training that may be of highest economic and social value, and arriving at some notion of the number of men who might profitably study to qualify themselves in the general grades.

The ground is sometimes taken that the usual undergraduate engineering course is a good preparation for almost any occupation and that therefore as many students as possible should be brought into engineering schools with the expectation that those among them who are best adapted for engineering careers will find it out, and go forward as engineers, while the others will do very well at something else. The movement towards a broader education for engineers, which is steadily gaining ground, . . . combined with the fact that engineering education is pretty expensive to the institution and in some cases to the student, gives emphasis to the importance of an adequate survey of the quanti-

tative needs of the country in engineering graduates. This would be by no means a small undertaking and probably could not be completed at the first effort, but might well be begun through the educational committees of the great engineering societies.

HAROLD D. HATFIELD, Dean, School of Applied Science, Howard University.

"I have been *unable to formulate* anything of a definite nature along the lines suggested in your letter.

"I assure you that I am *intensely interested in this work.*"

FRED E. AYER, Dean, College of Engineering, Municipal University of Akron.

"Does it seem logical to require a student to spend four years in improving his mind without teaching him anything about the workings of the mind that he is trying to improve? Ought not psychology to be required early in the course?

"I have been operating the part time system for sixteen years and if I had to choose, I should give up teaching rather than to go back to the full time method."

FRED W. SLADEN, Brig. Gen. U. S. Army, Superintendent, United States Military Academy.

"The great increase in the use of mechanical weapons and mechanical transportation in war during the last decade has created the demand on the part of the regular officers for a wider knowledge of mechanical engineering. The courses in engineering are now being re-cast to provide wider instruction in mechanical appliances and power.

"As military officers, the staff of the Military Academy is deeply interested in your plans for coördinating the engineering education of the nation. The important problems of this country will be more thoroughly and more promptly met if its man-power is educated in such a particular way that efficient engineers are available for the solution of every commercial and military problem.

"In this connection may I invite your attention to a memorandum prepared for me by Major Charles G. Mettler, Professor of Ordnance and Science of Gunnery."

MEMORANDUM FOR THE SUPERINTENDENT.

The nitrate deposits of Chile supply the greater part of our requirements of fixed nitrogen. The distance to Chile is great and the line

of communication is not defendable against a great combination of nations. Engineering education should be extended to provide a supply of engineers familiar with nitrogen fixation. The committee might seek the development of a field of labor for such engineers.

The production of high-grade optical glass in quantities has not reached a satisfactory condition in this country.

The production of cross-country automotive vehicles, which may be used independently of the limited highway, has not been developed to transport as rapidly as desired troops and munitions. There is a commercial field for engineers engaged in such work.

An important engineering problem appears in the slow construction of paved highways and in the costly maintenance of them.

There are numerous materials required for the defense of the nation which do not exist, and are not now producible within the boundaries of the nation. Substitutes must be provided before an adequate defense is assured. Rubber is one of the most important of these materials.

Another type of education which is closely related to engineering is the training of journeymen mechanics in the various trades. The World War demand for munitions emphasized the great lack of properly trained mechanics in all trades. There appears to be no supervision of the development of mechanics in any trade, except the requirements of the individual industries. And these industries prefer to develop special workmen, commonly known as machine operators, rather than the development of all-round mechanics. The old apprentice system seems to be breaking down, and it is not yet being supplanted by the trade schools of the country. The American Federation of Labor appears to pay more attention to this phase of our national life than any other organization, and its activities seem to lean more toward the limitation of the number of mechanics in any trade, than in the development of new ones. There is a demand for engineers who can train apprentices, journeymen and masters in all trades. It appears that the country is becoming over-specialized, and that there are insufficient trained mechanics to take up the work of producing munitions in time of war.

Several months ago the National Industrial Conference Board took up a line of investigation of engineering education, seeking to connect the education of our schools and colleges more directly with the industries, in which the graduates would be employed. The American Society of Mechanical Engineers has recently developed a code of ethics for engineers. It is suggested that the work of these two organizations could be considered by the committee of the Society for the Promotion of Engineering Education in connection with its investigations.

CHARLES G. MEYLER, *Major, Professor of Ordnance and Gunnery*
(In full.)

HELPFUL RELATIONS BETWEEN THE COLLEGE AND THE INDUSTRIES.

BY R. L. WALES,

Dean, Dept. of Engineering, Rhode Island State College.

The following notes deal with the problem of mutual helpfulness of the colleges and the industries. No attempt is made to present anything particularly original, but rather to assemble certain facts and suggestions in this connection, in an effort to present a fairly complete analysis of the problem.

The Relation of the College to the Industries.

Apparently college organizations may and should be of service to the industries by supplying

1. Trained men for
   - *A.* Industrial leaders.
     - (*a*) Routine engineers,
     - (*b*) Men capable of development into high-grade engineers,
     - (*c*) Industrial managers.
   - *B.* Rank and file of industrial workers.
2. Technical information.
   - *A.* Material already established but not readily available to the industry needing it.
   - *B.* Material of general or specific application obtained through an Engineering Experiment Station.

In the training of the men for any of the above forms of service, the end in view, the personal qualifications of the student, the course of study, the duration of the training period, and, above all, *the character of the instruction,* are controlling factors.

Very little specialization should be attempted in a four-

years' course. Fundamentals of mathematics, physics and chemistry, serving as a foundation for specialization later in any of the various fields in which a man may find himself, are of more value than highly specialized knowledge which may not meet the needs of a given case, and of which the underlying principles are hazy. Broad principles, rather than their application to any particular machine or process, should be stressed. Except for the psychological effect on the student, who tends to grow impatient unless given "real engineering" work, the time devoted to pure physics might well be increased in the average curriculum. The danger in presenting principles rather than special applications, which of course must be avoided, is that the work may become abstract and the student lose interest.

Much has been said of late on the matter of teaching fundamentals. Little or nothing has been said about the more important thing—*teaching fundamentally, i.e.,* connecting up apparently new and isolated facts or methods with the rock-bottom fundamentals, so that a student may "get his feet on the ground." Much more stress is needed on the necessity for a student to visualize and analyze each problem or project. Problems to be solved by "substituting in the formula" tend to defeat the very end of engineering training—the ability to assemble facts and to draw from them certain logical conclusions.

It should constantly be borne in mind that the point of view of the student should be quite different from that of the practicing engineer. The engineer is interested in getting accurate *results* in the *least possible time,* regardless of the method by which he gets them. Short cuts, formulae, tables and handbooks are invaluable to the engineer, so long as he *knows* that their application gives correct results.

To the student, however, results in themselves are of absolutely no value. The thing which should be of paramount interest to him is the *method* or *process* of *reasoning* which *leads* to correct results. The "answer" is of importance only

as an indication of mathematical accuracy and the application of sound reasoning. Short cuts, hand books, etc., are of immense value, but they, together with other forms of specialization, should come *after* the fundamental processes on which they depend are thoroughly understood.

As indicated in the opening outline, apparently three more or less distinct types of industrial leaders are needed.

There is always a vast amount of rather routine work of an engineering nature to be done in an industrial organization. This work is largely standardized in character, requires knowledge and training which cannot be expected of the "worker" class, but does not demand high-grade engineering ability, or the resourcefulness and breadth of view necessary for pioneer work. This field may be filled very satisfactorily by men who have had four years' training in the fundamentals of engineering and who have acquired the necessary specialized knowledge from the industry itself.

For those who wish to step from college already provided with any considerable degree of special training, and those who intend to take up work of investigation and research, a fifth year, following the four of basic training, is most desirable. Such an extension of the training period is almost absolutely necessary in order to bring the profession of engineering up to a parity with the other professions.

A third class of men which the college may furnish to the industries is represented by those who intend to become managers. This field of industrial management is comparatively new and is apparently extremely attractive.

It is recognized that those with engineering training, who have had experience in business and methods of production, make most successful industrial managers. This has led to an attempt to produce or duplicate such a product by dovetailing courses in engineering with those of business methods, in courses known as "Management Engineering," etc.

In this connection it must be remembered that the prototype had *four years* of *engineering training* (whether he apparently

made use of it all or not) and in addition, his experience in processes and business methods. In the dovetailing suggested the point may soon be reached at which the name "engineer" should no longer apply, and at which the merits of the engineering type of training, whatever they are, are lost.

Apparently it should be recognized that this is perhaps one of the most specialized branches of engineering; that specialization without the fundamentals is dangerous. Realizing these facts, some of those most widely experienced in this field of training are recommending as the best, perhaps the only satisfactory training, the normal four years of engineering work, followed by a fifth year of specialization along industrial lines.

In training for any of these forms of leadership, the aim should be, not to make the student of maximum value immediately on the day of his graduation, but to give him a foundation for growth so that he may later reach a much higher maximum. No industry should attempt to specify too minutely the type of work which will be most valuable to itself, both for the reason that this form may be perhaps least valuable for some other industry, and in attempting to meet these specifications, the college will miss the great fundamentals. Industrial leaders are quite generally recognizing that the duty of a high degree of specialization is theirs and not that of the college.

In the training of the rank and file of industrial workers the end in view should be almost the opposite of that in training the leaders. Here the object cannot be a chance for indefinite growth, but the development of the maximum immediate possibilities of a given man, both for his own sake and for the industry which he serves.

The courses of instruction are necessarily highly specialized, extremely practical, yet bound down to fundamental principles and common sense wherever possible.

The student who benefits from this type of work is the man already in industry, not the boy who thinks he sees in it an easy "short circuit" to becoming an engineer. For this reason

the so-called short course, involving work at the college, is usually not successful. Since the man who will benefit from the work cannot leave his employment to attend regular classes at college, the work must be taken to the man. This means the development of some form of extension course.

For this course there must be class or group organization, places of meeting provided, suitable instructors found, and programmes of instruction developed.

Organizations already in existence—employees of a given plant or factory, technical associations, labor organizations, Y. M. C. A. groups, may serve as a basis for class building, or entirely new associations may be formed for the specific purpose in hand.

Facilities for holding the meetings will frequently be provided gladly by industrial organizations interested in the development of their men. Association rooms and school houses may be secured for the use of other groups.

The choice of instructors is all-important. The average instructor in work of college grade is entirely unsuited in point of view and in habit of thought for much of this type of work. One who has grown up in the shops and has later had a college training will possibly make the most successful instructor. Local leader-instructors may be selected from among the most experienced in the group itself, these men working under the general suggestion and supervision of the college.

In connection with the matter of programme of work, one of the most serious difficulties is found in the wide variation in the previous experience and training, and the time available for work, of the different members of the class. Any fixed schedule of progress will be too slow for some and too fast for others. This results in a loss of interest on the part of a considerable portion of the class. Others will get behind and drop out on account of absences.

Information of a general character in connection with many subjects may be given by means of separate and independent lectures, the loss of one of which does not seriously lessen the

value of the others. This method is of course out of the question in cases where the student is expected to make systematic progress.

A combination of the regular class method with that of the correspondence school has apparently given considerable satisfaction in some instances. The instructor meets the class group at regular intervals, but works with students individually, explaining difficulties and making suggestions for their future work. The student reports through the mails and progresses as rapidly or as slowly as his individual powers and desires permit. By this plan the difficulties mentioned are avoided. Moreover it has the advantage over the normal correspondence course, coming from the contact, advice and inspiration of the instructor.

The course of instruction may be mapped out to meet the specific needs of the group in question and in harmony with the plans of any industry, board of trade, Y. M. C. A., or other organization which may be acting in coöperation with the college. Much material may be most conveniently presented in the form of mimeographed notes covering the essentials of the subject under consideration in such a style and from such a viewpoint as to be readily comprehended by the type of men being instructed. Also, textbooks which have stood the test of several years' successful use in this field of work, and covering a wide range of subjects, are now available.

It would seem that if the colleges carry out the above outlined types of instruction, with emphasis on the fundamentals of subject-matter, and especial emphasis on teaching fundamentally, they will be contributing their utmost toward industrial development in so far as the human side is concerned. Dangers to be avoided lie in fads and in wide departures from the old and tried methods in the adoption of those whose chief recommendation is that they are up-to-date.

Besides furnishing trained men for the industries, the college should become more and more a center to which industry may turn for technical information. Even a casual inspection

of many industrial plants makes it evident that there are the widest opportunities for economies in the application of information already at hand.

The economic return to the industries from the accumulation of new information through systematic laboratory investigation is now so well recognized as hardly to require mentioning. Of course the great industrial organizations are able to support private research laboratories, but for the host of smaller industries this is impossible. It would appear that in no other way could the college exercise so marked and so beneficial an influence on industry in general as through the activity of a well-equipped and well-manned engineering experiment station.

In order that the colleges may function in the way suggested, two things are necessary—funds, and a more cordial and less suspicious understanding between the colleges and industry. The latter is of prime importance.

Apparently such conditions could be brought about through better acquaintance. Worthwhile results might be accomplished if some well-qualified representative of the college could devote a considerable portion of his time to making such contacts with both managers and employees as would bring about such acquaintance and mutual understanding.

Relation of the Industries to the College.

The extent to which the colleges are able to give to the industries will be measured to a certain degree by the willingness of the latter to give in return.

These returns from the industries to the colleges may be classified in two groups—one material, the other psychological. Of the two, the latter is perhaps the more important.

Every teacher of engineering knows that one of his greatest difficulties is in maintaining a real, vital, sustained interest in many of the courses which experience has shown to be most worth while in developing the engineering attitude of mind. The "sophomore sag" is a very real thing. To the boy, fresh

from high school, there is little connection between most of his "theory" and the wheels that he sees spinning in a power plant. The fellow who has had some practical experience before entering college is almost universally the best engineering student. This is due less by far to the actual knowledge acquired in this experience than to the point of view which he has gained. The possible usefulness of his studies is at least glimpsed and his interest is more easily sustained.

The big thing, then, which the industries may do for the colleges is to help make engineering and the preparation for it real.

If the college is located in an industrial center, the part-time or coöperative course offers perhaps an ideal way in which to accomplish this result. For the rather isolated college, part-time work of the usual type seems impracticable. Except for the psychological effect of increased and sustained interest it would seem that more could be accomplished in unbroken terms in any case.

Perhaps a possible substitute for the part-time course for the isolated college would be a coöperative plan by which students could be taken into the industries during the vacation period. This would have the advantage of a less disturbed programme, but would be far less valuable from the point of view mentioned. Also it would probably be more difficult for the industries to meet such a seasonal requirement.

Another way in which the industries may give life to the academic work of the college is by the preparation for the schools of real engineering problems—which their organizations have met in actual practice. This is the plan which the Westinghouse Company has so well inaugurated recently. Such problems may be, and frequently are, exactly similar to those made up in the class room, but their psychological effect on the student is quite different.

Most helpful of all might be a plan whereby the industries should send *carefully chosen* representatives, not only to explain their processes and advertise their products, but to show

wherein the actual training which the students are receiving finds *application* in their particular line of work.

The most harmful man, from the point of view of engineering training, is the so-called engineer who boasts before students that in all his many years of experience he has never made use of this, that, or the other subject they happen to be studying. He fails to mention, probably to *realize,* that in many instances, while he *didn't* use these things, nevertheless he *might have done so* with great advantage if he hadn't been too rusty.

The positive rather than the negative side of the value of training should be presented. This cannot be done effectively by instructors on account of the suspicion of bias. It could be done with very fruitful results by the proper men from the industries.

In addition to the psychological assistance mentioned, the industries may be helpful in more material ways.

Moving-picture studies of processes and operation of machines, together with accompanying lectures, are helpful in a rather superficial way, but frequently leave but a hasty and blurred impression on the student's mind. Most trade literature which is now supplied contains material of interest to the prospective purchaser, but little with respect to the "inside workings" and "reasons why" in which the engineer is interested. To be of real value to the colleges, literature should be prepared from the point of view of technical interest rather than that of sales or the ordinary "instruction sheet."

To be helpful to the colleges, and through them to themselves, the industries should forget about "trade secrets," many of which are no secrets at all. If the industries and the colleges are to coöperate to their mutual advantage, their relations must be open and frank.

An instance of the opposite spirit recently came to the writer's attention. At a certain gathering of those interested in oil technology, a prominent member took occasion to cast ridicule upon the description of the process of producing

boiled linseed oil, as given in a text prepared by one of our leading technical educators. He stated that of all the processes which *might* be used, the one given certainly *never was* used.

Assuming the statement to be a fact, whose was the fault? Can a man who assembles information of that character in suitable form for students, be expected to cover only such ground as come within the range of his own individual experience? Texts would indeed be meagre if such were the case. If, in order to hide a trade secret, manufacturers give out false information, and this finds its way into text-books from which students are supposed to acquire technical information, where lies the fault?

It has long been an ethical and a practical principle of the professions that information is most valuable when pooled. The industries might profitably adopt the same principles, at any rate in their dealings with the colleges.

Again the solution seems to lie in the direction of better acquaintance, less suspicion and a more thorough mutual understanding. The recent convention of industrial and college heads was a movement along the right path. If each one of those heads would transplant the "get-together" idea locally, so that the entire organizations which they represent might know more of each others' problems, valuable results might follow.

By way of brief summary it may be stated:

The problem of the mutual assistance of the colleges and the industries may be analyzed from two points of view—one considering the possible contributions of the college toward industrial success, and that of the reciprocal relation of the industries toward the college.

The apparent duty of the college is to supply adequately trained men for the various phases of industrial leadership and operation, and to serve as centers of information to which the industries may turn for assistance in the solution of technical problems.

In the training of industrial leaders the need is suggested

for stressing the fundamentals rather than specializations, a type of teaching which develops in the student the habit of getting back to simple, rock-bottom principles, the distinction in the points of view of the student and the practicing engineer, and the desirability of a fifth year for any highly specialized form of college instruction.

In the training of industrial leaders the object is the possibility of future growth, while in the case of the rank and file, it is immediate usefulness.

For the workers there become necessary the extension course, commonsense practical training, a peculiarly qualified type of instructor and special forms of class organization.

Besides supplying trained men for the industries, the colleges may be of the greatest value through their organizations for consultation and research.

The industries in their turn may contribute to the mutual well-being by helping to impress on the students the reality of engineering and the *usefulness* rather than the *uselessness* of engineering training. The part-time course, specially prepared literature, talks by carefully chosen representatives, may serve the purpose.

Policies of guarding trade secrets by giving false information, and the general attitude of suspicion, are deplorable.

The way out seems to lie in the direction of increased opportunities for frequent intercourse, and the more cordial understanding of each other's problems which comes with better acquaintance.

SHOP VISITS BY INDUSTRIAL ENGINEERING STUDENTS AT NEW YORK UNIVERSITY.

BY WM. F. TURNBULL,

Instructor in Mechanical Engineering, New York University.

A class of fifteen students was assigned to visit and report on one industrial plant each week, and the results of this course prompt a few remarks on the following topics:

1. Motive underlying trips.
2. Substance and style of reports.
3. Attitude of plant executives and employees.
4. Method of conducting trips.
5. Where coöperation by firms would be most helpful.

1. The object of these trips was to familiarize the student with the atmosphere of industrial plants, the general fundamental process of various major industries, forms of shop organization, methods of handling material and methods of controlling production.

To accomplish this, the instructor visited each plant beforehand and went over the route which the students were to follow, becoming personally acquainted with the foremen of the different departments and sections, explaining to the firm the particular object of the trip, and carrying away as much information as possible for a preliminary talk at the University. In addition certain definite questions were formulated and noted by the students to be answered in the reports.

The importance of such preliminary work can hardly be exaggerated, since many of the students have not seen the inside of a manufacturing plant, or at least, few of them have done more than walk through and "see wheels go round," and one who is thoroughly familiar with the plant can form no conception of the bewilderment of the student at being con-

ducted through a maze of machinery without first having studied the route.

2. The substance and style of the reports were held to be such as would be acceptable for an article for a technical magazine, or in special cases, such as would be expected from the assistant to an executive making a survey of the plant. On this account it was necessary in many cases to limit the trip to one or two departments of a plant. The metal industries were first considered, the first trip being to an iron foundry, the second to a drop forging plant, third, heavy machine shop, fourth, light automatic machine shop. In each of these, only one department was inspected in detail, but its relation to the whole plant pointed out. Then followed visits to concerns making steel castings, bolts, roofing felt, elevators, rubber shoes, pianos, paneled doors, and a printing establishment. This gave a variety of departmental organization, type of buildings and state of plant efficiency. Some inefficient plants were visited with the idea of getting the students to suggest plans for their improvement and thus test their planning powers and practical sense.

In addition to the above, visits were made to the Engineering Laboratories of the Western Electric Company, to demonstrate the importance to production of perfected design and the experimental research necessary; to a plant making can-making machinery for the purpose of studying a routing and cost system which has been worked out with unusual care; and to the Bush Terminal warehouses and manufacturing loft buildings to illustrate the importance of convenient transportation of material as an element in successful production.

In almost every report the student was required to answer such general questions as the following:

Advantages or disadvantages of location with respect to transportation, labor supply and cost of land.

Types of buildings and whether construction and arrangement is suited to the industry.

Method of generating power and driving machinery.

Names of machines, including maker, type and dates of manufacture when obtainable. No student was allowed to report that he saw a steam engine, a motor, planer or drill, but detail was called for.

General diagram of plant, sometimes given by instructor and checked by student.

Process chart of product, and similar chart of shop orders and records necessary to production.

Method of payment of labor and its results.

Handling and storage of stock, work in progress and finished parts.

Tool room and supply system of plant.

In addition to the above, a certain number of shop terms were required to be defined, with a thumb-nail sketch added when necessary.

Stress was laid not only on accuracy of information, but on balancing of space devoted to different topics, logical arrangement, correct English and neatness of sketches, topical headings and spacing of material. These matters are apt to be neglected by engineering students due to the undue emphasis placed upon technical details.

3. The attitude of executives and employees of the various plants visited has been one of the utmost friendliness and cordiality. In many cases the cordiality was even embarrassing, in that they wished to show us the entire plant when we preferred to specialize on some particular features. The idea of an industrial study as contrasted with merely "seeing things" seems to be novel and not quite comprehensible. However, in most cases, our idea was fully grasped and the trip planned by the Company in a special way so as to meet our requirements. The trips in which the students showed the greatest interest were those on which we saw most of the system of production control, routing, scheduling and follow-up methods.

4. The method of conducting the trips varied according to

the convenience of the firm in supplying guides. In most cases the class was split into small groups of four to six, in some cases eight and in a few cases all traveled as one group. The best number in a group is four and not more than five, in order that the guide may be able to answer questions and to make himself heard in noisy rooms. In some cases guides were selected from the sales force, in others they were follow-up men, in other cases a clerk conducted the group from department to department and the individual foreman explained the workings of his own department. In still other cases the Assistant to the President or to the General Manager conducted the whole party. The ideal method of conducting such a trip is for the whole party to call at the office of some chief executive who greets the students, and says a few words about the business as a whole, its growth and prospects and the particular policies which the firm thinks are its own and particularly good. The party should then divide into small groups and visit the Order Department or Sales Department, then the Production or Planning Department or whatever is its equivalent, then the Drafting Room, then the various shops in which each foreman should explain his own department, showing how the work is executed from the drawing, shop order or operation sheet. Attention should be called to the machines used, kind of labor and method of handling, where the material comes from to the particular department and where it goes from there.

In addition to the operation sheets and what might be called the motive power of production, the observers should then note the time tickets and records of work done and follow these to the Cost Department. The method of drawing material from stock and accounting for the same should be noted, also the method of keeping inventory and figuring depreciation. It may be objected that this is going too far into the accounting end but as a matter of fact, this is the life of the business and without it the machinery could not run. The party

should then re-assemble and return to the office of the chief executive or whoever was seen at the beginning where questions of a general nature can be answered, as such questions may be embarrassing to a subordinate or may be such as he is unable to answer. Furthermore questions will occur regarding the relations between different departments. Finally the executive can put the party in an enthusiastic frame of mind which is the greatest factor in the success of a trip and in the student's future recollection of that firm. The student tends to generalize from accidental observations of a particular plant to the industry as a whole.

5. The most helpful avenues of coöperation on the part of the industries have already been hinted at and may be summarized as follows: Personal interest of the chief executive in planning trip in collaboration with the instructor and in giving him preliminary information, meeting students face to face, giving access to planning and cost departments as to their methods, which need not divulge any private information, assigning sufficient number of guides who are familiar with plant as a whole, have good voices, can talk slowly and explain matters in language not too technical, interesting the foremen so that they will undertake the tiresome task of explaining their departments to several groups in succession, and if possible furnishing students beforehand with descriptive literature or blueprints showing organization of plant and the why and wherefore of its workings.

It has been said that the questions, What, How, Why, indicate three progressive stages of mental development. The average shop visits are conducted on the basis of "what" to see, and ocasionally, "how" does it work. It is however necessary from the point of view of Industrial Engineering to go on the basis of "why" and "why not." Most of the students are critical, expecting an ideal state of things everywhere, and these trips furnish opportunities to give them a more practical point of view. The real science of shop inspection centers around contact with the chief executive and

bringing him to feel the importance of a serious study, which is not merely a sight-seeing tour. It also gives him a chance to observe the young men under circumstances which promote naturalness of behavior often absent in a formal interview, and in this way good material from among the students may sometimes be picked out.

LABORATORY COURSE IN ELEMENTARY MECHANICS AT THE UNIVERSITY OF ALBERTA.

BY J. W. CAMPBELL,
Associate Professor of Mathematics.

That there is difficulty in satisfactorily teaching mechanics will be readily granted by those who have had experience with classes in the subject. It has been said that the fundamental principles of mechanics are more poorly understood by students than those of almost any other subject. In view of this fact it has been decided at a few engineering schools to conduct a laboratory course in elementary mechanics to help to lay a clear foundation of ideas on which the student can afterwards build. Such a laboratory course has been given at the University of Alberta for the past two years, and it is the purpose of this note to indicate the manner and point of view with which the work is being carried on.

For the original suggestion that the scheme should be adopted here and for much of the preliminary planning the writer can claim no credit, as this was done prior to his appointment to the staff in the summer of 1920. Although the course is conducted by the Department of Mathematics, the plans for it were developed by the Departments of Mathematics, Civil Engineering and Physics. Among those who deserve special mention in this regard are Dean Boyle and Professors Wilson, Morrison and Sheldon. The work of the course has been conducted in the Civil Engineering building and much of the credit for whatever success has been attained is due to the very cordial coöperation of Professor Wilson, the head of that department.

The course is taken by all students in the Freshman year of Engineering. It consists of one three-hour period per week

for the year, and is taken in connection with a lecture course of two hours per week. In planning the course it was decided that so far as possible the experiments should be as nearly as possible *on an engineering scale rather than on a physics scale.* This aspect of the work may be illustrated by reference to some of the experiments performed.

Constant Acceleration.—A two-inch steel ball is allowed to roll down a planed steel angle six feet long, slightly inclined, and the constancy of the acceleration verified. At first it was not possible to obtain satisfactory results owing to the angles being not quite true, but this difficulty has been overcome by putting on a truss and clamp arrangement which can be adjusted by the student until the angle is true as tested by a level.

Impact.—Cast iron spherical balls up to fifty pounds are suspended from a frame eight feet high, and the conservation of momentum for both direct and oblique impact is verified. For measuring displacements pointers are inserted in the balls so as to just clear a horizontal beaver board underneath.

Parallelogram Law of Forces.—Weights are supported from quarter-inch ropes, two of which pass over pulleys in which the friction factor is small. By pulling the weights down in turn and easing them back three positions of equilibrium are obtained, and assuming that the frictional resistance of each pulley is the same in opposite directions the effect of friction can be eliminated and the parallelogram law confirmed.

Moment of Inertia.—A fly-wheel is mounted on conical ball-bearings and its moment of inertia estimated by allowing weights attached to a string wound around the shaft to accelerate the wheel. The wheels are of about forty pounds' weight and are so made that the theoretical value of the moment of inertia can be fairly easily calculated and used as a check.

Dynamics of a Ball Rolling Down an Inclined Plane.—The same equipment is used as is used for the constant acceleration experiment, and the theory of the motion of the ball verified. By varying the inclination of the steel angle the effect of rolling friction is eliminated.

Ballistic Balance.—The muzzle velocity of a .22 rifle bullet is calculated by firing several bullets into a wooden block.

Screw-Jacks.—An ordinary screw-jack is used and its efficiency estimated by lifting weights up to two tons.

Pulley-Systems.—Half-inch rope is used and the efficiencies of various combinations of blocks and pulleys is obtained by lifting loads of upwards of two hundred pounds. The effects on the efficiency of twists in the ropes, etc., such as may arise in practice, are also observed.

Elasticity, Stretching.—Wires of about twenty-five feet length are stretched by varying loads and the amount of stretch measured directly by a vernier arrangement. There are also group demonstrations on the testing machine of the stretching of half-inch steel rods to the breaking point.

Hydrodynamics.—The relation between the velocity of a water jet from an orifice to the head of water is verified, and the brake horse-power of a Pelton wheel is measured.

The other experiments which have so far been included on the syllabus are:

Restitution	*Simple Pendulum*
Friction	*Compound Pendulum*
Principle of Moments	*Elasticity, bending*
Centers of Gravity	*Torsion*

This list, of course, is incomplete. It represents a number of the most fundamental topics but a number of additions are contemplated. A Cusson's Attwood's machine has just been received and it will be used in the following sessions, and it is hoped to include some more experiments on couples and rotational motion. The inclusion of catalogue apparatus, however, is avoided as much as possible, the Attwood's machine and the Torsion apparatus being the only two pieces of equipment which have not been made either in the university machine shop or in local foundries.

In conducting the course there is the usual difficulty experienced in laboratory work of having students perform an experiment before they have had the theory on which it is based.

Such an order stimulates interest in the class work but unfortunately in many cases the students are unable to appreciate fully the significance of the experiment. In an endeavor to minimize this difficulty the apparatus has been sufficiently duplicated so that not more than four different experiments are conducted at a time. Four demonstrators are engaged in the laboratory for the first hour of each period, each demonstrator being in charge of some one of the experiments being conducted that day. The several pairs of students who are to conduct a given experiment are first instructed by the demonstrator in charge as to the principles involved and the manner in which the work is to be carried out. The experiments assigned are kept as little in advance of the classroom work as possible. This plan is felt to be preferable to the issuing of syllabus sheets to the students.

The purpose that it is desirable to achieve in a first course in mechanics no doubt differs with different instructors. In the mind of the writer it is most desirable that the student acquire a clear and connected understanding of fundamental mechanical principles rather than a knowledge of rules and formulas which with practice he may juggle successfully in the solution of problems. The fewer fundamental principles to be accepted as independent, the simpler and more concise does the subject become. For this reason statics is treated in the classroom as a special case of dynamics. The parallelogram law of forces, for example, is then a consequence of the laws of motion, and its verification is interpreted as a confirmation of those laws. It is recognized by the student not only as a useful law in itself, but as a part of a larger structure. The principles of moments, of couples, etc., become similarly regarded. The advantage of such a scheme is to give greater confidence in a piece of subtle analysis, for the danger of circular reasoning is largely avoided, and the validity of the premises of an argument can be better tested.

With this point of view in mind it is endeavored to have the experiments performed regarded as consisting of two classes.

In those of the first class the purpose is (*a*) to test where possible the accuracy of the consequences of the axioms assumed, and (*b*) to test the accuracy of the empirical laws assumed such as the law of friction, the law of restitution, and Hooke's Law. The experiments of the second class consist in using the fundamental principles obtained (*a*) to solve problems, such as to find the muzzle velocity of a rifle bullet and (*b*) to investigate the working of various types of machines.

It is perhaps premature at this time to speak much of the results obtained. The course itself is in the experimental stage and several of the experiments have been modified after observing the experience of students with them. But it is sufficiently clear that there is a real interest in the work on the part of the students and that their appreciation of the theory of mechanics is increased. In the work of the past year one student found difficulty in believing that the linear momentum imparted to a body is independent of the point of application of the force. He tried testing for himself by means of a suspended book but could not get satisfactory results. It is hoped to facilitate and encourage the testing in the laboratory of difficulties such as this which arise in class work.

A REVIEW OF DRAWING FROM S. P. E. E. PROCEEDINGS, 1893–1921.

BY ROBERT F. EDGAR,

Instructor in Civil Engineering, University of Pittsburgh.

Drawing for Engineering Students. By CHARLES DENISON, Professor of Drawing, University of Michigan. Volume 1, page 270.

If, with Philip Gilbert Hammerton, we say that "drawing is a motion which leaves significant marks," we find ourselves embarrassed by the comprehensiveness of a definition which confessedly includes writing. Let us consider as acceptable the following definition from the Century Dictionary which defines drawing as, "The act of forming or tracing lines, as with a pen, a pencil, etc. Specifically in the fine arts, the act or method of representing objects on a surface." In other words drawing is either the act or method of representing objects on a surface.

What should be embraced under the term "drawing?" If it is an act or method of representation, should it include the mental processes which precede but lead to the act? For example, descriptive geometry, which is purely mathematical, is included under the subject of drawing, while drawing, strictly speaking, is used only as a means of representing the mental operations and illustrating the result, yet the treatment of this topic "drawing for engineering students" would be conspicuously incomplete were we to omit the consideration of so important a part of the work.

The skillful handling of a pencil and the manipulation of instruments is one thing; while the knowledge of mathematical form, the intellectual insight into space, which comes only after a careful study of projections, is quite another. The writer's conception of the most important ends to be kept in view are three in number:

1. The training and enlargement of scientific imagination.

2. The cultivation of the powers of observation and of visual memory.
3. The attainment of skill in representation.

Skillful representation of manual dexterity in the use of the instruments is usually the inexperienced student's idea of success in the drafting room. He forgets that it is an idea, an exact scientific record of facts which he has to deal with, not an artistic production only. The first and most important requirement of a drawing is that it must be correct, and legible. As a matter of fact no technical drawing is above suspicion or unclouded in its claim to credibility, which betrays lack of training on the part of the draftsman, or lack of knowledge in so simple a matter as correct formation of letters and figures. A certain amount of time should be put in on making the drawing neat. Many students obtain that result at a great outlay in time and effort, yet no labor should be spared in making the drawing accurate and legible. Legibility has to do principally with lettering. To one considered a successful draftsman, few parts receive less attention than lettering. After establishing our confidence in his natural ability, oftentimes the draftsman shakes that confidence by disfiguring his drawing with wretched formation of letters and figures to such an extent that the true import of the drawing is jeopardized.

What has thus far been said relates largely to results obtained by training the hand.

The higher value of the study and practice of drawing is the education and expansion of certain faculties, without which eminent success in any branch of engineering is doubtful, while one possessing these faculties, possesses striking advantages over his uncultivated rival.

The cultivation of the powers of visual memory is very well illustrated in freehand drawing. The ability to make an accurate rapid sketch of an object is of great value to the engineer. This is his expression of ideas, while the draftsman is delegated to transfer those ideas by the time-

consuming process of drawing up his plans. This is an essential qualification for those aspiring to leadership in the engineering profession. Freehand drawing tends to increase the student's knowledge of the relation of point to point and line to line, also his powers of observation. The study of descriptive goemetry is admirably adapted to the expansion of these powers of observation and actual mental picturing.

The method of projections, while lacking the beauty of freehand drawing and descriptive geometry, is sufficiently precise, and at the same time supplies a most perfect graphical presentation of the body under investigation.

It is this method of projection which gives the student the familiarity of complex shapes and increases his imagination to such an extent that an immense gain in economy and thought will be attained.

The writer believes that the first two years' work in drawing should include geometrical drawing, freehand drawing, lettering and above all thorough discipline in descriptive geometry and its practical applications.

Mechanical Drawing. J. J. FLATHER, Professor of Mechanical Drawing, Purdue University. Volume II., page 113.

As drawing is the language of the engineer, it is of the greatest importance that the student be properly taught to express himself and that his methods conform to those in vogue among practical men. A drawing that requires explanation does not fulfill its mission. It should be self-explanatory.

As freehand sketches enter into the work of the engineer, the importance of teaching freehand drawing cannot be overestimated. It is a wonderful aid in the cultivation of the powers of observation and the first step in drawing is to see accurately.

The student's first work should consist of drawing straight lines, both horizontal and vertical, followed by exercises with curved lines and circles in flat, followed by a few examples in shading. After this, simple objects and machines should be given to sketch. The relationship existing between the several

views of the object should be thoroughly impressed upon his mind. Exercises in lettering should begin with the first work in freehand drawing and should continue throughout the course. From four to eight hours per week may be advantageously devoted to this work the first term of the freshman year.

Instrumental work should then be taken up. Machine pieces and simple machines suited to the capacity of the individual should be given the student for reproduction. Above all let the student assume that his drawing is going to the shop to be worked from.

Tracing and blue printing should be taken up at this time and the work of the term completed by a series of graded exercises in isometric drawing, shading and tinting. To carry this work through successfully, will require from six to ten hours per week for a period of twenty-four weeks.

At the beginning of the sophomore year a short course in Descriptive Geometry should be given, including shades and shadows. About five to eight hours per week for a period of sixteen weeks should suffice for this work.

A course should then follow preparatory to machine design in which inspection of machines should be taken up, tearing down of machines and making sketches and detailed drawings of parts.

One lecture and from five to eight hours per week of inspecting, sketching and drawing may be very advantageously devoted to this subject.

We advocate the following course in mechanical drawing for the Freshman year.

Freehand drawing and lettering.....	96 hours.
Instrumental drawing Tracing Blue printing Shading Tinting Isometric drawing	..... 192 hours.

A General Course in Civil Engineering. C. L. CRANDALL, Professor of Civil Engineering, Cornell University. Volume III, page 268.

In Professor Crandall's paper on "A General Course in Civil Engineering" we find the following material on drawing.

Instruction in lettering should begin early in the course; skill and rapidity can then be acquired in furnishing regular drawings, rather than in practicing lettering itself. Three hours per week is recommended for this course.

Freehand drawing and sketching should require three hours per week.

Descriptive Geometry is recommended for twelve hours per week, giving time for plenty of problems in all four angles, with the idea of developing the imagination in the student and have him do his own thinking.

A Course in Mechanical Engineering. Subjects to be Treated and Time given to Each. By H. W. SPANGLER, Professor of Mechanical Engineering, University of Pennsylvania. Volume III, page 284.

Work in the drawing room should continue throughout the entire four years, but the student should be taught to draw in the first half year. He should first learn to use the instruments. His work should be copy work and he should be required to do his work with great accuracy and neatness. When this is accomplished the teaching of drawing as such should be at an end. Inaccurate work thereafter should be rejected as a matter of course. This should require about three hours per week for half a year.

This should be followed by teaching the student how to draw objects, the methods of placing the drawing and the making of sections, etc. This should take the balance of the year, say three hours per week. Lettering should be included throughout the course.

In the second year the student should be taught what to draw for engineering work. He should be given sketches of

various engineering problems and be required to make working drawings. The use of sketches in this connection should require three hours per week for the second year.

The third year may be commenced with the actual making of sketches, as the student now knows what a sketch should include and the connection between the sketch and the object and between the sketch and the finished drawing. Portions of machines may be torn down and sketches made of the various parts preliminary to making the working drawing. This should be used in connection with the student design work and should require about three hours per week for the first half of the third year.

While no one will claim that such a course will teach a student to design, it will develop that faculty called common sense which every engineer must possess if he wishes to be a success in his particular line of engineering.

The True Place of Drawing and Shop Work in Engineering Colleges. By CHARLES H. BENJAMIN, Professor of Mechanical Engineering, Case School of Applied Science. Volume III, page 126.

Before we can intelligently discuss the subject of drawing it is necessary to determine why drawing is taught at all in Technical colleges.

The value of drawing in stimulating the imagination, in training the memory and as a means of expression, is not for the engineer alone but for any man. One great aim of any school should be the training and development of the mental powers of its students, and those are the most successful teachers who can teach in such a way as to insure this.

I would give freehand drawing a prominent place in a course of drawing, for when properly taught it is the higher type and requires more thought and more originality than mechanical drawing. Freehand sketches are used to express the ideas of designs which the draftsman is to draw up.

It is best to begin freehand drawing by copying single forms of machine details from the objects themselves, then to advance to more complex forms.

Following this the mechanical drawing should be taught in accordance with drafting room practice. It is also well to have the students work from drawings from outside firms in order to familiarize themselves with the various types of drawings.

Drawing Shopwork and Engineering Laboratory. Practice in Engineering Colleges. By HARRY E. SMITH, Assistant Professor of Mechanical Engineering, University of Minn. Volume VII, page 176.

In Professor Smith's paper no mention is made of drawing except to draw a comparison of the amount of drawing given at a number of different institutions, a copy of which is shown herewith:

University	Hours	Weeks
Cornell	9	35
Columbia	5	28
University of Illinois	11 2/3	33
Iowa State Agric. College	4½	31
Lehigh	6	34
M. I. T.	8	30
Univ. of Minn.	8	22
Univ. of Mich.	6	33
Purdue	8 2/3	37
Univ. of Wis.	3¾	35
Worcester Poly. Inst.	3	30

The Work of the Freshman and Sophomore Years of Engineering Courses. By FRED A. FISH, Professor of Electrical Engineering, Iowa State College. Volume 15, page 205.

Professor Fish in his paper merely compares the work of the freshman and sophomore years by the use of a chart.

That part referring to Elementary Drawing in Freshman and Sophomore years is as follows:

School		Hours
Case School		174
Clarkson Inst.		72
Cornell University	M. E.	153
	E. E.	153
	C. E.	306
University of Illinois		216
Iowa State College	M. E.	96
	E. E.	96
	C. E.	48
	Mm. E.	96
Lehigh	M. E.	51
	E. E.	51
	C. E.	51
	Mm. E.	102
University of Mich.		..
University of Minn.		252
University of Nebraska		162
Ohio State University	drawing	244
	lecture	44
Purdue University		216
Texas A. & M. College	M. E.	162
	E. E.	162
	C. E.	194
University of Wis.		140
Worcester Poly. Inst.		170
University of Kansas		120

Descriptive Geometry. Its Importance in the Engineering Curriculum and the Methods of Teaching It. By OTIS E. RANDALL, Professor of Mechanics and Mechanical Drawing, Brown University. Volume 15, page 619.

Since projection has been adopted as a medium of graphic representation, and used in engineering, the student of engineering should acquire a working knowledge of the fundamental principles of the system. Whether the study of pure descriptive geometry, which deals with the fundamental principles

of projection, should be given so much space in the engineering curricula, is a question of varied opinions.

The direct or apparent results from the study of descriptive geometry, the ability to intelligently and skillfully use the various forms of projection in the representation of magnitudes of great complexity, is only one advantage derived from such study. The unique and vital part which the study of descriptive geometry plays in the development of the mind is the one which makes the subject of such importance in the engineering curricula.

There is a tendency in engineering schools to lay stress on courses which are practical in nature, which supply the needed information best, without requiring mental effort or resulting in mental development. We are inclined to forget that intellectual development is the prerequisite of breadth of vision, depth of insight and soundness of judgment, qualifications without which a man will make poor use of the best opportunities. The nature of the material with which the subject deals, calls for a form of mental exercise whose value is seldom appreciated. The study of descriptive geometry greatly increases the power of comprehensive thinking. The power to concentrate on a single matter to the exclusion of all others is of great value.

Our system of projection enables us to place upon a single sheet many views of the same object through this medium; to comprehend at a glance the nature, relation and combination of the various parts which make up the whole, but frequently before the design has reached the stage where it can be represented on paper, the mind is called upon to consider simultaneously the details of a large assemblage of parts. Is there any subject the study of which can do more toward the development of this altogether too uncommon power than descriptive geometry. Many men today who use this power with so much freedom, little know how much they owe to the study of descriptive geometry. The practical results of such a study, valuable as they may be, are small in importance when com-

pared with the subtle influence which the oft-repeated and still fruitless efforts to understand, had upon the development of the mind.

The Educational Side of Engineering Drawing. By THOS. E. FRENCH, Professor of Engineering Drawing, Ohio State University. Volume 21, page 99.

The analogy between drawing and language is often referred to. I prefer to go further in saying that drawing, as a mode of thought expression, is a real and complete written language, with its orthography, its grammar and its style, its idioms and abbreviations. In teaching it we are not only preparing the student in the subject needed in his course, but, from the nature of it, have in one hand an exceptional cultural subject for strengthening the power and habit of exact thinking, that most difficult of all habits to fix, and for training the constructive imagination, the perceptive ability which enables one to think in three dimensions, to visualize quickly and accurately and to build up a clear mental image.

As one has said, it is "the power and habit of observing accurately, that marks one of the fundamental differences between the incapable man and the man of power." As to the need of drawing, let me quote from an address of a few years ago by President Elliott. "I have recently examined all the courses offered by the university and I find but one, the course of theology, in which a knowledge of drawing would not be of immediate value." The power to draw is greatly needed in all courses and absolutely indispensible in some of them.

Dean Schaler says, "The value of drawing in all departments of science, not only as a language, but as a discipline of the mind, can hardly be overestimated."

With this conception of the subject, that it is of great value for mental discipline and training in space intuition, engineering drawing becomes, with the possible exception of

mathematics, the most important single branch of study in the technical school. We must not regard engineering drawing merely as a course for the purpose of teaching the student how to hold a T-square and make lines with a ruling pen, but rather as a course for strengthening the power and habit of exact thinking.

You may recall when there were fewer textbooks on the subject of drawing and when Warren was the standard. The students of those days could project anything anywhere but knew little of a working drawing.

A great amount of time was spent on revolution, shades and shadows and the laborious tinting of cylinders, spheres, etc. After blueprinting came in they still followed custom instead of becoming acquainted with up-to-date drafting-room practice.

It is in the present-day demand for the "practical" that there lies the danger of losing sight of the educational value of a subject that has in it the greatest combination of possibilities for the correlation of theory and practice. We must not forget the training of the student in the power of space conception and clear thinking when trying to show him in the quickest way possible how to make a working drawing.

Mathematics is given for the student's subsequent use, and for exercise in reasoning. The training of the perceptive ability and imagination in drawing may seem apart from pure reasoning, yet if you agree that the foundation of right reasoning is accurate perception, it ought greatly to strengthen the power of logical demonstration.

Disregarding the copying courses, which do little more than show certain standards of execution, the methods now in use may be divided into two classes, those which begin with the point, line and plane and progress to the solid and those which begin with the solid and afterwards take up the analysis of lines and surfaces.

Considering the first division all the older books on drawing began with the projection and revolution of a point. The schools using this method however usually began with a textbook on descriptive geometry.

The synthetic method seems logical, but few students are able to understand it clearly. They start with a hazy idea and often never come to a clear realization of its purpose or its beauty. It is this failure in comprehension on the part of the student that gives descriptive geometry its bad reputation.

When we consider that many men after leaving college fail to appreciate the perceptive development and mental training that they have received from the study of descriptive geometry, how much more is it true that a student with his undeveloped mind, thrown head first into descriptive geometry, can not realize that it has any value either cultural or practical. Since real benefit is attained by involuntary attention, the full benefit of descriptive geometry can not be attained from this class except in remote cases.

While there is more than one route to a given destination the second method, that of taking up orthographic projection by the use of the solid followed by descriptive geometry, not only has the support of abundant proof in experience, but can be defended psychologically as well. The student gets his space intuition more clearly by handling concrete forms than by attempting to imagine points and lines revolving in space.

The beginning course should contain both orthographic projection and pictorial projection. The objects chosen should be real machine or structural parts so far as practicable. Lettering should be taken up at the beginning of the course, not the kind with frills and flourishes but a simple freehand lettering stroke should be used.

While it is really descriptive geometry I prefer to call all this "Engineering drawing," engineering drawing rather than "mechanical drawing." The term "mechanical draw-

ing'' is an unfortunate misnomer which may mean either drawing with mathematical instruments or the drawing of mechanical things. Engineering drawing covers the whole field of technical drawing and the important part could be taught with a pencil and a pad of coördinate paper.

In outlining a course the first thing should be an explanation of the purpose of the subject, calculated to arouse interest, followed with descriptions of shop methods as they apply, and of drafting room methods, also organization and management.

Good form should be insisted on in the handling of the instruments, as it is a graphic language and the beginner must have skill in its recording. While the percentage of graduates who start in at drafting is small yet he must know good work from experience with it.

After accuracy comes speed. Time limits should be put on all drawings and it should be considered derogatory rather than meritorious to put in extra time in the drafting room.

The time spent on blackboard drill, say one hour per week, is a good investment. It is in these recitations that the first exercises in reading and writing the language may be had. Working up the visualizing ability by such methods, having the instructor draw the perspective view and the students draw the orthographic views will become interesting to the student and he will enjoy his own introspection. After the student has mastered this, the process should be reversed.

The student should be able to look at the drawing and see the object. He should also be able to look at the object and see the drawing and decide quickly the views which best represent it. Sketching and working drawings should be made use of to a large extent in connection with this work of visualizing.

With a preparation such as this, and the consequent power of reading description from lines, descriptive geometry if introduced now, becomes real and fascinating.

In conclusion let me contend for a better recognition of the general department of engineering drawing including descriptive geometry. Let it not be incorporated with any department but rather let it be a separate department.

Finally, let us have drawing taught well and understandingly, not only for its own sake, but for the sake of the subjects that follow and for the student's sake, for whom, with the power it awakens, it really becomes drawing in relation to life.

Constructive Drawing in High Schools and Engineering Colleges. By L. F. RONDINELLA, Professor of Constructive Drawing, West Philadelphia High School for Boys. Volume 22, page 397.

Most of the Engineering Colleges complain that students entering from many high and preparatory schools have had no instruction in drawing and many high and preparatory schools complain that their graduates entering colleges are given no credit for courses in drawing, that in some cases amounted to as much as four hundred classroom hours. We believe that our engineering colleges would be justified in adding to their entrance requirements at least one hundred classroom hours in constructive drawing. We believe for such elementary instruction, the schools should be given by the colleges, entrance credits equal to those allowed for the same number of hours in science laboratory work.

We recommend that the preparatory schools should be required to cover thoroughly the following ground.

(1) A review of the geometric terms used to describe the different kinds of lines, angles, surfaces and solids.
(2) An understanding of, and familiarity with, the machine draftsman's units of measure.
(3) Practice to gain facility in the use of the ordinary instruments.

(4) Inking in exercises to familiarize the student with the different kinds of line conventions used on a working drawing.

(5) A clear explanation of the difference in the two methods of expressing the shape of a solid object.

(6) It should be impressed upon the student that a complete working drawing should contain

(*a*) As many geometric views of the object as are necessary to express completely the facts of its shape and construction.

(*b*) All the dimensions that are necessary and desirable.

(*c*) The title or name of the object.

(*d*) The scale or proportion which the line of the drawing bears to the corresponding edges of the object.

(*e*) The notes or necessary information as to the number of parts needed, the material, the surfaces to be finished, etc.

Freehand sketching should be taught to some extent. It has considerable educative value in training the student's eye in judging proportions and in training the hand in rapidly drawing lines with approximate but increasing accuracy. The mere copying of other mechanical drawings should be discouraged.

Good lettering should be insisted upon and should be under close supervision from the start of the course, since practice in forming the letters wrongly, establishes habits often difficult to correct.

Finally the preparatory schools should be impressed with the fact that constructive drawing has large educative value if taught to train the student's brain, his hand and his eye; and that this training will be of great use to him whether he applies it in drafting room or in an engineering course of study.